The New Genomic Semicommons

Anna B. Laakmann*

In Association for Molecular Pathology v. Myriad Genetics*, the Supreme Court held that isolated genomic DNA constitutes patent-ineligible subject matter but that laboratory-created complementary DNA (cDNA) is patent eligible. This result makes sense as a matter of innovation policy, since it places genomic DNA into the research commons while maintaining patent eligibility for cDNA used to discover new drug targets and to produce therapeutic biologics. However, the decision's flawed reasoning based on misconceptions of products and laws of nature could have wide-ranging negative effects on the nascent field of personalized medicine. Although* Myriad *ostensibly averts an anticommons tragedy associated with gene patenting, the decision may in fact worsen a growing commons problem in medical research. Heightened uncertainty surrounding the patentability of complex, data-driven discoveries could undermine socially productive sharing regimes by altering the private payoffs associated with cooperation. Rising patent-eligibility hurdles coincide with intensifying regulatory scrutiny of medical diagnostics. The obvious concern is that the combination of an inability to patent genomic inventions and higher regulatory barriers to market entry could decimate the fledgling industry supporting personalized medicine. However, perhaps counterintuitively, a carefully crafted regulatory scheme actually could promote innovation by acting as a "visible hand" to coordinate the generation and dissemination of patent-ineligible genomic information.*

* Associate Professor, Lewis & Clark Law School. B.A., Williams College; M.D., University of Pennsylvania; J.D., Stanford University.

INTRODUCTION

In *Association for Molecular Pathology v. Myriad Genetics*,[1] the Supreme Court addressed a seemingly straightforward question: "Are human genes patentable?"[2] The Court's cryptic response exposed but left unexamined numerous scientific and legal intricacies embedded into this query. The posed question rested on a flawed assumption that the concept of a human gene has a stable, uniform meaning. It also mistakenly suggested that the patent eligibility of a DNA molecule could be satisfactorily determined without considering the patentability of claims to methods of using and manipulating the genetic information incorporated therein. In declining to engage with this complexity, the Court created more questions than it answered regarding the patent eligibility of genomic discoveries. The legal uncertainty aggravated by *Myriad*'s ambiguity extends beyond claims to genetic molecules to touch upon all scientific research that involves the processing of biological information. Hence the decision has significant implications for the nascent field of personalized medicine.[3]

Myriad is the third in a line of four patent-eligibility cases that the Supreme Court has considered since 2010.[4] In *Bilski v. Kappos*,[5] the Court revived its long-dormant eligible subject matter jurisprudence to hold that a method for hedging risk in commodities trading constituted a patent-ineligible abstract idea.[6] While

1. Ass'n for Molecular Pathology v. Myriad Genetics, 133 S. Ct. 2107 (2013).

2. *See* Petition for Writ of Certiorari at *i, *Myriad*, 133 S. Ct. 2107 (No. 12-398), 2012 WL 4502947 ("This case therefore presents the following questions: 1. Are human genes patentable?"); *Myriad*, 133 S. Ct. at 694–95 (2012) (granting petition for writ of certiorari granted limited to Question 1 presented by the petition).

3. *See infra* Part I.

4. The Court's recent patent-eligibility cases include *Bilski v. Kappos*, 561 U.S. 593 (2010) (business methods); *Mayo Collaborative Servs. v. Prometheus Labs.*, 132 S. Ct. 1289 (2012) (diagnostic methods); *Ass'n for Molecular Pathology v. Myriad Genetics*, 133 S. Ct. 2107 (2013) (human genes); and, most recently, *Alice Corp. Pty. Ltd. v. CLS Bank Int'l*, 134 S. Ct. 2347 (2014) (computer-implemented inventions).

5. 561 U.S. 593 (2010).

6. *Id.* at 609–12.

breathing new life into the judicially created exceptions to patent eligibility,[7] the *Bilski* Court stressed that a careful approach should be taken in future patent-eligibility determinations. It instructed that the Federal Circuit's "machine-or-transformation" test should not be the sole method to determine the patent eligibility of inventions in the information age because rigid adherence to this test "would create uncertainty as to the patentability of software, advanced diagnostic medicine techniques, and inventions based on linear programming, data compression, and the manipulation of digital signals."[8]

Yet in the intervening years the Court seems not to have heeded its own admonition to tread lightly when considering the patent eligibility of information age technologies. In *Mayo Collaborative Services v. Prometheus Laboratories*, it unanimously held that a claimed method of determining optimal dosages of thiopurine drugs to treat autoimmune diseases recited unpatentable laws of nature.[9] The following year the Court decided *Myriad*, holding that isolated DNA taken from a naturally occurring molecule was patent ineligible, but synthetically created complementary DNA (cDNA) was patent eligible.[10] Most recently, in *Alice Corp. v. CLS Bank*, the Court held that a computer-implemented scheme to mitigate settlement risk in financial transactions was drawn to an unpatentable abstract idea.[11]

Though the Court's perseveration on patent eligibility suggests that it is mired in a "metaphysical morass," the core practical concern with which it has been grappling is the type and amount of human activity that renders something patent eligible.[12] Hovering at the margins of the Court's opinions are normative questions about how patent law should adapt to a technological shift away from the mechanical inventions of the industrial age toward more information-based advancements lacking tangible embodiments. The Court has justified its renewed use of the patent-eligibility doctrine as necessary to preserve a robust public domain.[13] Yet, contrary to the Court's unstated presumptions, patent-eligibility restrictions do not define a sharp dichotomy between open and proprietary

7. Section 101 of the Patent Act states that a patent may be granted to "[w]hoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title." 35 U.S.C. § 101 (2012). There are, however, longstanding judicially created exceptions to eligible subject matter: "laws of nature, natural phenomena, and abstract ideas." Diamond v. Diehr, 450 U.S. 175, 185 (1981).

8. *Bilski*, 561 U.S. at 605.

9. *Mayo*, 132 S. Ct. at 1294.

10. *Myriad*, 133 S. Ct. 2107 (2013); *see also infra* Section I.A.

11. Alice Corp. v. CLS Bank, 134 S. Ct. 2347, 2357 (2014).

12. *See* Rob Merges, *Selected Thoughts on a Myriad of Problems*, SCOTUSBLOG (Feb. 6, 2013, 12:35 PM), http://www.scotusblog.com/2013/02/selected-thoughts-on-a-myriad-of-problems [http://perma.cc/7JK5-JFEH].

13. *See, e.g.*, *Mayo*, 132 S. Ct. at 1301 ("[E]ven though rewarding with patents those who discover new laws of nature and the like might well encourage their discovery, those laws and principles, considered generally, are 'the basic tools of scientific and technological work.'" (quoting Gottschalk v. Benson, 409 U.S. 63, 67 (1972))).

innovation. The *Myriad* Court did not consider the ways in which its decision might alter the complex dynamics between patents, secrecy, and the genomic commons.[14]

Part I of this Article places *Myriad* in context by highlighting the ways in which the case, in conjunction with other recent patent-eligibility decisions, may limit the patentability of data-driven advances in personalized medicine. Part II discusses the implications of a potential turn toward secrecy as a means to appropriate patent-ineligible genomic discoveries. Additionally, it explains how collective action problems in genomics research relate to the central challenge of drawing boundaries between public and private property in a manner that encourages cooperation among disparate groups with conflicting interests. Part III reviews how recent changes to patent-eligibility standards coincide with an evolving regulatory scheme for diagnostic products. It proposes ways in which regulation by the U.S. Food and Drug Administration (FDA) may be employed to coordinate open and proprietary research by incenting the production and disclosure of patent-ineligible genomic information. The brief Conclusion summarizes the Article's main points.

I. *MYRIAD* IN CONTEXT

A. Misconceptions of "Natural" Products and Laws

1. Composition Claims

In ruling on the patent eligibility of gene sequences, the Supreme Court in *Myriad* tacitly accepted the lower courts' conceptions of DNA as uniquely capable of transmitting biological information. The district court had found that Myriad's product claims constituted patent-ineligible subject matter because, "DNA represents the physical embodiment of biological information, distinct in its essential characteristics from any other chemical found in nature."[15] The Federal Circuit reversed this part of the district court's decision by reasoning that DNA is better described in patents by its chemical structure than by its informational properties.[16] But the Federal Circuit did not refute the district court's characterization of DNA as the singular embodiment of biological information.

The Supreme Court implicitly endorsed this form of "genetic exceptionalism"[17] in holding that isolated DNA taken from a naturally occurring

14. *See infra* Part II.

15. Ass'n for Molecular Pathology v. USPTO, 702 F. Supp. 2d 181, 185 (S.D.N.Y. 2010); *see also id.* at 228 (stating that a DNA sequence "serves as the physical embodiment of laws of nature—those that define the construction of the human body").

16. Ass'n for Molecular Pathology v. USPTO, 689 F.3d 1303, 1330 (Fed. Cir. 2012).

17. "Genetic exceptionalism" refers to the view that genetic information is qualitatively different from other types of information and therefore should be treated differently. *See* Thomas H. Murray, *Genetic Exceptionalism and "Future Diaries": Is Genetic Information Different from Other Medical*

molecule is patent ineligible but laboratory created cDNA is a patent-eligible composition of matter.[18] The Court reasoned that Myriad's claims on isolated DNA did not satisfy § 101 requirements for patent eligibility because Myriad's proprietary interest was in naturally determined genetic information, not chemical compositions.[19] Nonetheless, the Court held that cDNA is patent eligible because such molecules are man-made laboratory creations, even though the nucleotide sequence of cDNA is also dictated by nature.[20]

In addition to being logically incoherent, the Supreme Court's *Myriad* opinion reinforced the lower courts' apparent misunderstanding of fundamental principles of biochemistry. DNA undoubtedly is an essential molecule that contains the requisite molecular code for intracellular protein formation. But it is hardly unique in its capacity to embody information; all chemical entities communicate with each other in a thermodynamic sense.[21] Indeed, all human functions stem from complex cascades of signaling events between biological molecules within and across cells.[22] Like mechanical and electronic systems, biological systems essentially comprise an organized series of components that store and transmit information.[23] The Supreme Court's opinion elides these fundamental principles and without explanation places DNA molecules in a special category for patent-law purposes.

The Court's opinion also perpetuates judicial misperceptions about scientists' understanding of genes. In his dissent from the Federal Circuit's finding that Myriad's composition claims were patent eligible, Judge Bryson stated, "[b]iochemists extract the target genes along *lines defined by nature* so as to preserve the structure and function that the gene possessed in its natural environment."[24] Judge Bryson's depiction fails to recognize that genes are social constructs, not

---

Information?, *in* GENETIC SECRETS: PROTECTING PRIVACY AND CONFIDENTIALITY IN THE GENETIC ERA 60, 61 (Mark A. Rothstein ed., 1997).

18. Ass'n for Molecular Pathology v. Myriad Genetics, 133 S. Ct. 2107, 2107 (2013).

19. *Id.* at 2118.

20. *Id.* at 2119; *see also* Dan L. Burk, *Are Human Genes Patentable?*, 44 INT'L REV. INTELL. PROP. & COMPETITION L. 747 (2013) (explaining how the Court applied an informational framework in the first half of its opinion dealing with isolated DNA, but pivoted away from this framework in the latter half of its opinion dealing with cDNA).

21. *See Myriad*, 133 S. Ct. at 2111; Dan L. Burk, *The Curious Incident of the Supreme Court in Myriad Genetics*, 90 NOTRE DAME L. REV. 505 (2014).

22. *See* Dan L. Burk, *The Problem of Process in Biotechnology*, 43 HOUS. L. REV. 561, 583 (2006) ("DNA . . . is not the only informational component and it does not exist in isolation. It rather functions within an interactive structural apparatus that as a whole forms an information transfer system."); *see, e.g.*, *Signal Transduction V1*, WIKIMEDIA COMMONS, http://commons.wikimedia.org/wiki/File:Signal_transduction_v1.png [http://perma.cc/WFM6-E6PV] (illustrating a signal transduction pathway).

23. *See* Kevin Emerson Collins, *The Knowledge/Embodiment Dichotomy*, 47 U.C. DAVIS L. REV. 1279, 1313 (2014) ("DNA carries information within biological systems and triggers behaviors through deterministic processes, just as many embodiments of inventions carry information to mechanical and electronic devices and trigger behaviors through deterministic processes.").

24. Ass'n for Molecular Pathology v. USPTO, 689 F.3d 1303, 1353 (Fed. Cir. 2012) (Bryson, J., dissenting) (emphasis added).

self-evident entities with contours precisely dictated by nature.[25] Often protein-coding and noncoding regulatory elements are distant from each other along the primary DNA sequence, but physically quite close in three-dimensional space on a chromosome.[26] Scientists have long debated whether the concept of a gene should be limited to the portion of a DNA sequence that codes for protein, or instead should include noncoding regulatory elements as well.[27] The burgeoning field of epigenetics has further challenged scientists to rethink their notion of the gene by upending the central dogma that nucleotide sequences solely determine heritable traits.[28]

The Supreme Court's *Myriad* opinion propagates the legal fiction propounded in *Diamond v. Chakrabarty*[29] that principled lines can be drawn between unpatentable products of nature and patent-eligible, man-made creations. In truth, the search for such illusory lines inevitably leads courts and commentators down a metaphysical rabbit hole. The lines that end up being drawn through application of the product-of-nature exception ultimately rest on subjective judgments about what should and should not count as "natural" for purposes of patent law.[30]

Though the *Myriad* Court couched its decision in scientific language, it based its holding that isolated DNA is patent ineligible on an unstated subjective judgment that the primary nucleotide sequence is the only informational content within a genetic molecule that is pertinent to patent eligibility and that other structural and functional attributes should be disregarded when making patent-eligibility decisions.[31] But *Myriad*'s equation of "human genes" with primary

25. Dan L. Burk, *Edifying Thoughts of a Patent Watcher: The Nature of DNA*, 60 UCLA L. REV. DISC. 92, 95 (2013) ("'There is no entity in nature that comes with a label declaring 'This is a gene,' . . . . The concept of a gene is entirely a human construct . . . .").

26. Mark B. Gerstein et al., *What is a Gene, Post-ENCODE? History and Updated Definition*, 17 GENOME RES. 671 (2007); *see also* Burk, *supra* note 22, at 586 ("[I]t is the three-dimensional configuration of the molecule, as well as its associated physical structures, taken in the context of a complex molecular system, that encodes biological information.").

27. Gerstein et al., *supra* note 26, at 669 (reviewing how the concept of the gene evolved in the period between 1860 and the early twenty-first century).

28. *See, e.g.*, Guy Riddihough & Laura M. Zahn, *What is Epigenetics?*, 330 SCIENCE 611, 611 (2010) (noting that DNA sequences do not fully explain the heredity of complex traits, and defining an epigenetic system to include nongenetic elements that are "heritable, self-perpetuating, and reversible"); Danielle Simmons, *Epigenetic Influence and Disease*, 1 NATURE EDUC. 1 (2008) (explaining how genetic control factors other than an individual's DNA sequence can be passed down through generations); Stephen S. Hall, *The Genome's Dark Matter*, MIT TECH. REV. (Dec. 21, 2010), http://www.technologyreview.com/featuredstory/422142/the-genomes-dark-matter [http://perma.cc/YCW8-NB4K] (describing studies suggesting that genetic effects may be transmitted by non-DNA molecules).

29. Diamond v. Chakrabarty, 447 U.S. 303 (1980) (holding that a bacterium genetically engineered to break down crude oil was patent-eligible subject matter).

30. Burk, *supra* note 25, at 97 ("[T]he product of nature doctrine invites its devotees to indulge in a mad search for some aspect of an invention that might be considered *un*natural."). *Alice* continues the journey down the rabbit hole in search of patent-ineligible abstract ideas. Alice Corp. Pty. Ltd. v. CLS Bank Int'l, 134 S. Ct. 2347 (2014).

31. Burk, *supra* note 21, at 509.

nucleotide sequences belies the scientific reality that native DNA is part of a complex structure whose spatial configuration determines its biological function.[32] If the functional attributes of a DNA sequence change when the nucleotides are extracted from their native environment, is it accurate to conclude that the observed qualities of isolated DNA are nature's handiwork? Such questions make for interesting philosophical fodder, but cannot lead to satisfying answers to questions of patent eligibility.

The Supreme Court's disposition of the particular composition claims at issue in *Myriad* seems reasonable as a matter of innovation policy since it places genomic DNA into the research commons while maintaining patent eligibility for cDNA used to discover new drug targets and to produce therapeutic biologics.[33] But its faulty grounding in the product-of-nature doctrine obscures the patentability boundaries for future biotechnology discoveries.[34] As the Federal Circuit's recent decision in *In re Roslin Inst.* demonstrates, *Myriad* casts a shadow over a wide swath of biomedical innovation.[35]

2. Method Claims

In reviewing Myriad's claims on DNA sequences, the Supreme Court oddly made no reference to its *Mayo* decision in which it had applied the law-of-nature exception to deem claimed diagnostic methods patent ineligible.[36] As Dan Burk notes, the Court's silence is particularly puzzling given *Myriad*'s procedural history.[37] The *Myriad* Court thus left unresolved questions about the contours of the law-of-nature exception to patent eligibility and its relationship to the product-of-nature exception.[38] Perhaps the Court was wary of probing *Mayo*'s shaky

32. Burk, *supra* note 25, at 99–100; *see, e.g.*, *The Twisted Leukemia Genome: A Third Dimension to Cancer Genomics*, BIOME (Apr. 30, 2014), http://www.biomedcentral.com/biome/the-twisted-leukemia-genome-a-third-dimension-to-cancer-genomics [http://perma.cc/LHJ7-MLCY] (explaining how the three-dimensional shape of genetic material in leukemia cells defines leukemia subtypes).

33. *See* Arti K. Rai, *Biomedical Patents at the Supreme Court: A Path Forward*, 66 STAN. L. REV. ONLINE 111, 114–15 (2013) (noting that the Court's distinction between genomic and cDNA accords with economic arguments contained in amicus briefs filed by the Solicitor General and the geneticist Eric Lander).

34. Burk, *supra* note 21, at 507 (illustrating this point with the example of an artificially created molecule that carries the same nucleotide sequence as native DNA).

35. *See In re* Roslin Inst. (Edinburgh), 750 F.3d 1333, 1337–39 (Fed. Cir. 2014) (relying on Ass'n for Molecular Pathology v. Myriad Genetics Inc., 133 S. Ct. 2107 (2013), to hold that a cloned mammal is not patent-eligible subject matter because the patent specification and claims do not describe the clones to have "markedly different characteristics from the donor animals of which they are copies").

36. *See* Ass'n for Molecular Pathology v. Myriad Genetics Inc., 133 S. Ct. 2107 (2013); Mayo Collaborative v. Prometheus Labs., 132 S. Ct. 1289, 1303–04 (2012).

37. Burk, *supra* note 21, at 506 (noting that the Supreme Court vacated and remanded the Federal Circuit's original *Myriad* decision in light of the Court's *Mayo* decision, yet when it ultimately decided *Myriad* it failed to explain the relationship between the law-of-nature and product-of-nature doctrines).

38. The *Myriad* Court seemed to conflate the two exceptions during the course of its decision. The Court began by stating that "a naturally occurring DNA segment is a *product* of nature and not

foundations—like the product-of-nature doctrine, the law-of-nature doctrine has no solid scientific underpinning.[39]

The Supreme Court did not assess the patent eligibility of Myriad's claimed methods for comparing and analyzing cancer-associated gene sequences in its review of the Federal Circuit's decision.[40] By dodging *Mayo* and accepting that Myriad's diagnostic method claims were patent ineligible without further exposition, the Court perpetuated uncertainty about the precedential effect of this aspect of the Federal Circuit's ruling. The district court had found Myriad's method claims patent ineligible on the ground that they were unpatentable "abstract mental processes."[41] The Federal Circuit upheld this part of the district court's decision on appeal.[42] However, its muddled rationale for finding the method claims patent ineligible conflated ostensibly distinct categorical exceptions to patent eligibility. In one part of its opinion the Federal Circuit concluded that the method claims covered "abstract, mental steps."[43] Later it justified its holding with reference to the Supreme Court's ruling in *Mayo* that the diagnostic claims in that case were patent-ineligible natural laws.[44] Since the Supreme Court elected not to address Myriad's method claims, the meaning of this portion of the Federal Circuit's decision remains unclear, as it may depend on whether the claimed methods recite patent-ineligible "abstract, mental steps" or "laws of nature."[45]

In citing *Mayo* as justification for invalidating Myriad's diagnostic claims, the Federal Circuit reinforced misconceptions of scientific knowledge that form the tenuous basis for the Supreme Court's law-of-nature doctrine. Contrary to the Court's suggestion in *Mayo*,[46] human interpretations of collected data are not laws that spontaneously spring forth from nature. Although one could characterize the processes whereby a patient metabolizes thiopurine drugs and those metabolites interact with the human body as natural in some sense, correlations drawn from recorded results are man-made artifacts. Notably, the information contained in the

---

patent eligible," but later explained that Myriad's claim on isolated gene sequences "fell squarely within the *law* of nature exception." 133 S. Ct. at 2111, 2117 (emphases added).

39. The meaning of the term "law of nature" continues to be hotly debated by philosophers of science. *See* Funk Bros. Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 135 (1948) ("Everything that happens may be deemed 'the work of nature,' and any patentable composite exemplifies in its properties 'the laws of nature.'") (Frankfurter, J., concurring); Burk, *supra* note 21, at 518–19 (explaining how the Court has repeatedly misconstrued Einstein's theory of relativity as a natural principle rather than a product of human ingenuity). *See generally* THE OXFORD COMPANION TO PHILOSOPHY 506–07 (Ted Honderich ed., 2d ed. 2005) (discussing various philosophical approaches); Franklin Gin & David Demeritt, *Nature: A Contested Concept*, *in* KEY CONCEPTS IN GEOGRAPHY 300, 303 (Nicholas J. Clifford et. al eds., 2009).

40. *Myriad*, 133 S. Ct. at 2119 ("[T]here are no method claims before this Court.").

41. Ass'n for Molecular Pathology v. USPTO, 702 F. Supp. 2d 181, 185 (S.D.N.Y. 2010).

42. Ass'n for Molecular Pathology v. USPTO, 689 F.3d 1303, 1309 (Fed. Cir. 2012).

43. *Id.*

44. *Id.* at 1333.

45. *Id.* at 1331–34.

46. Mayo Collaborative v. Prometheus Labs., 132 S. Ct. 1289, 1297 (2012) (asserting that the claimed correlation "itself exists in principle apart from any human action. . . . [a]nd so a patent that simply describes that relation sets forth a natural law").

patents at issue in *Mayo* shows that the claimed clinical correlations between metabolite levels and drug toxicity and efficacy did not uniformly apply to all patients.[47] The fact that the defendant, Mayo Collaborative Services, used a different range of metabolite values in its allegedly infringing diagnostic test reflects the element of human judgment incorporated into the claimed methods.[48]

By electing to leave *Mayo* undisturbed, the Supreme Court in *Myriad* signaled its continued support for a law-of-nature doctrine that mischaracterizes the scientific process and disregards the subjective, fallible aspects of diagnostic claims. Scientific studies generate data, but the interpretive findings gleaned from such data represent imperfect human comprehension of observed phenomena.[49] To underscore this distinction, Stanford epidemiologist John Ioannidis has theorized that most published research findings are probably false and estimates that in data-driven fields like genomics just one in a thousand can be expected to prove correct.[50] In sustaining a misplaced focus on discerning products and laws of nature, the *Myriad* Court thereby sidestepped critical questions about how patent law should treat newly generated scientific knowledge.[51] This oversight creates serious innovation policy problems as we embark on an era in which data interpretation and analysis form the crux of technological progress.

B. Personalized Medicine at the Intersection of Myriad, Mayo, *and* Alice

1. From Single Genes to Big Genomic Data

The Supreme Court described Myriad's principal scientific contribution as identifying the precise chromosomal location and nucleotide sequence of the BRCA1 and BRCA2 genes.[52] But this characterization of Myriad's invention belies the complexity of clinical genomics research. Myriad's main scientific accomplishment was in linking genetic, genealogical, and clinical data to develop an accurate predictive test for cancer risk.[53] After it had identified the BRCA1 and BRCA2 genes, Myriad turned them into medically useful biomarkers by correlating particular mutations with disease susceptibility.

BRCA1/2-related cancer screened by Myriad is a clinical outlier in that

47. *See* U.S. Patent No. 6,355,623 B2 (filed Apr. 8, 1999) (tables listing patients' metabolite levels and clinical outcomes).

48. *Mayo*, 132 S. Ct. at 1295–96 (noting that Prometheus and Mayo used slightly different metabolite levels to determine toxicity).

49. Rebecca S. Eisenberg, Prometheus *Rebound: Diagnostics, Nature, and Mathematical Algorithms*, 122 YALE L.J. ONLINE 341, 344 (2013) ("[N]ature supplies the raw data, while human judgment is necessary to interpret the data and to guide medical intervention.").

50. *Unreliable Research: Trouble at the Lab*, ECONOMIST, Oct. 19, 2013, at 26.

51. For a suggested approach to the treatment of newly generated scientific knowledge, see Collins, *supra* note 23, at 1282, for a proposal to patent-eligibility determinations that draws a distinction between patent-eligible "embodiment-advances" and patent-ineligible "knowledge-advances."

52. Ass'n for Molecular Pathology v. Myriad Genetics Inc., 133 S. Ct. 2107, 2116 (2013).

53. *Id.* at 2117 n.4 (reciting text from the Detailed Description of the Patent).

mutations in these genes alone significantly increase disease risk.[54] Unlike lay notions of genetic determinism, most traits and conditions cannot be attributed to mutations in individual genes or groups of genes.[55] The penetrance of disease-associated mutations typically is highly context dependent and modified by various regulatory elements that can alter their deleterious effects.[56] In the majority of cases, information about numerous biological and clinical factors is required to make accurate diagnostic and prognostic clinical assessments. Even some of the seemingly most straightforward monogenetic diseases have turned out to be more complex than originally perceived. For example, after scientists identified the gene associated with cystic fibrosis, an inherited condition thought to follow a recessive Mendelian inheritance pattern, they were surprised to learn that mutations in both copies of the gene do not always cause the disease.[57]

The complexity of the scientific puzzles has led genomics researchers to develop increasingly sophisticated diagnostic tools. Advances in whole genome sequencing, which identifies a person's entire set of roughly three billion nucleotide base pairs, soon will make single-gene diagnostic tests like Myriad's BRCAnalysis® obsolete.[58] Scientists tackling tremendously complicated problems are moving away from the narrow study of individual genes toward a systems approach to clinical diagnostics that relies on ever-improving means for generating, storing, and manipulating information.[59] Researchers use laboratory tests, biosensors, scanners, medical records, and social media to obtain multiple

54. Ass'n for Molecular Pathology v. USPTO, 702 F. Supp. 2d 181, 203 (S.D.N.Y. 2010) (noting that women with BRCA1 and BRCA2 mutations have up to an eighty-five percent cumulative risk of breast cancer and up to a fifty percent cumulative risk of ovarian cancer).

55. DOROTHY NELKIN & M. SUSAN LINDEE, THE DNA MYSTIQUE: THE GENE AS A CULTURAL ICON 96 (1995); Philip R. Reilly, *Genetic Discrimination*, *in* GENETIC TESTING AND THE USE OF INFORMATION 106, 127 (Clarisa Long ed., 1999) (noting frequent lay "references to the 'shopping' gene, the 'thrifty' gene, and other biological absurdities").

56. Hall, *supra* note 28.

57. Gina Kolata, *Cystic Fibrosis Surprise: Genetic Screening Falters*, N.Y. TIMES, Nov. 16, 1993, at C1 (discussing studies showing that gene mutations do not always result in cystic fibrosis and sometimes only lead to infertility or asthma, and noting a physician's conclusion that these findings demonstrate that "there is, in fact, no such thing as a single-gene genetic disorder").

58. Even if Myriad's isolated DNA claims had not been found patent ineligible, whole genome sequencers plausibly could have argued that they did not infringe Myriad's claims because their methods do not involve isolation of individual genes. *See* Christopher M. Holman, *Debunking the Myth that Whole-Genome Sequencing Infringes Thousands of Gene Patents*, 30 NATURE BIOTECH. 240, 240 (2012); W. Nicholson Price II, *Unblocked Future: Why Gene Patents Won't Hinder Whole Genome Sequencing and Personalized Medicine*, 33 CARDOZO L. REV. 1601 (2012); *see also* Blake Atkinson, Comment, *Patents Without Teeth: Whole Genome Sequencing and Gene Patent Infringement After* AMP v. Myriad, 54 JURIMETRICS 65 (2013) (arguing that whole genome sequencing is unlikely to infringe any of Myriad's surviving patent claims).

59. *See, e.g.*, Jim Kozubek, *Why Can't We Prevent Alzheimer's?*, ATLANTIC (Jan. 30, 2014, 1:30 PM), http://www.theatlantic.com/health/archive/2014/01/why-cant-we-prevent-alzheimers/283256 [http://perma.cc/4Q68-43QF] (noting that sequencing the human genome has not led to treatments for common diseases with diverse genetic etiologies and explaining how Alzheimer's researchers are shifting to a "networks" approach that studies dynamic interactions among groups of intracellular molecules).

layers of data and generate digitized profiles of subject populations. They view the human body as a dynamic information system and its genome one of several different components that interoperate in an iterative fashion to determine how it functions.[60]

In the new era of cloud computing and whole genome sequencing, data collection is relatively cheap and easy.[61] Institutions and companies are generating a torrent of genomic data as the cost of sequencing falls.[62] The core research challenge for contemporary researchers is in organizing and analyzing immense data sets and extracting meaningful information.[63] Unlike the simple correlations at issue in *Mayo* and *Myriad*, clinically valid associations may be quite difficult to find.[64] Indeed, genome-wide studies of genetic variants linked to common, polygenic diseases currently explain only a fraction of the inherited disease risks.[65]

2. Convergence of Information Processing Technologies

Although *Myriad, Mayo,* and *Alice* dealt with different types of inventions, the cases converge around core issues about the patent eligibility of information-based products and processes.[66] A key question running through these cases is how patent law should govern advances in the ways in which information is captured, used, and manipulated that do not involve the creation of new physical objects. The threads of this inquiry intersect in the personalized medicine arena, which marks the conceptual and practical intersections of the life sciences and the computer sciences.

Conceptual features shared by these scientific disciplines are reflected in the

---

60. Eric J. Topol, *Individualized Medicine from Prewomb to Tomb*, 157 CELL 241, 242 fig.1 (representing the "Geographic Information System of a Human Being," including the genome, transcriptome, proteome, metabolome, microbiome, epigenome, and exposome).

61. Steven L. Salzberg & Mihaela Pertea, Correspondence, *Do-It-Yourself Genetic Testing*, 11 GENOME BIOLOGY 404 (Oct. 7, 2010), http://www.genomebiology.com/content/pdf/gb-2010-11-10-404.pdf [https://perma.cc/E759-E5UF] (noting that it will soon be cheaper to sequence a patient's entire genome before testing for mutations than to conduct multiple single-gene tests).

62. *See* Ken Terry, *Big Data Analytics*, INFORMATIONWEEK, Mar. 1, 2013, at 8, 8–15 (describing several big data projects designed to investigate genetic links to disease, including one run by Kaiser Permanente funded by a $25 million grant from the National Institutes of Health); Oswaldo Trelles et al., Correspondence, *Big Data, but Are We Ready?*, 12 NATURE REV. GENETICS 224 (2011) (discussing big data genomics research).

63. Topol, *supra* note 60, at 245 ("Identifying the signal from the noise, with the vast majority of variants categorized as 'unknown significance' (VUS), is the crux of the challenge.").

64. *See, e.g.*, Michael M. Hopkins & Stuart Hogarth, *Biomarker Patents for Diagnostics: Problem or Solution?*, 30 NATURE BIOTECH. 498, 499 (2012).

65. *See* David Altshuler et al., *Genetic Mapping in Human Disease*, 322 SCIENCE 881, 885 (2008) (noting that genome-wide studies of variants associated with Type 2 diabetes can explain only five percent of the inherited risk of the disease).

66. *See* Burk, *supra* note 22, at 588–89 (observing that biotechnology and computer software constitute information technologies in which the distinction between product and process is problematic); Rai, *supra* note 33, at 114 (noting that the Court in *Myriad* missed an opportunity to provide guidance not only to the biopharmaceutical industry but to industries dependent on software and data processing).

language used to explain them. Genomics researchers have adopted the lexicon of computer science to describe genetic architecture. The genetic code has been compared to computer hardware and epigenetic information analogized to software that controls the operation of the hardware.[67] Another popular metaphor characterizes the genome as an operating system for a human being and genes as sloppily coded subroutines in this overall system.[68] Recognition of the common information processing aspects of biomedical and software technologies has begun to creep into the courts' patent jurisprudence. Although the Supreme Court in *Mayo* found the diagnostic claims at issue to be unpatentable natural laws, it did not reach this conclusion by reference to prior cases involving natural phenomena. Rather, the Court relied on two prior cases involving computer-implemented inventions—*Parker v. Flook* and *Diamond v. Diehr*—as the "cases most directly on point."[69] By the same token, the Federal Circuit has compared computer-implemented software to mental processes that occur within human minds.[70]

Personalized medicine merges life science and computer science on a more concrete level. Diagnostic and therapeutic developers rely on sophisticated software to mine big genomic data and to decipher links between biomarkers and disease.[71] The Supreme Court's recent patent-eligibility cases collectively create substantial uncertainty about the patentability of advances in personalized medicine based on computer-driven interrogation of large quantities of raw data.[72] Do the combined results of *Mayo*, *Myriad*, and *Alice* render even highly complex, computer-implemented analyses of observed phenomena unpatentable? That is, can an algorithm that interrogates and interprets aggregate genomic and clinical data qualify as an "inventive concept" that makes it a patent-eligible application of laws of nature?[73] The answer to this question remains unclear, but recent

67. Dana C. Dolinoy et al., *Epigenetic Gene Regulation: Linking Early Developmental Environment to Adult Disease*, 23 REPROD. TOXICOLOGY 297, 298 (2007).

68. Gerstein et al., *supra* note 26, at 675 (emphasizing that gene transcription occurs in a "'higgledy-piggledy' fashion, very much like what would be described as sloppy, unstructured computer program code . . . .").

69. Eisenberg, *supra* note 49, at 343.

70. *See, e.g.*, Cybersource Corp. v. Retail Decisions, Inc., 654 F.3d 1366, 1371–73 (Fed. Cir. 2011) (invalidating software claims because they encompassed steps that could be mentally performed by humans).

71. *See, e.g.*, Ryan McBride, *Amgen Claimed Big Data Software Prize in $415M deCODE Buyout*, FIERCEBIOTECHIT (Mar. 31, 2013), http://www.fiercebiotechit.com/story/amgen-claimed-big-data-software-prize-415m-decode-buyout/2013-03-31 [http://perma.cc/9WQ5-7H5P] (noting that the biotechnology firm Amgen bought Iceland-based deCODE Genetics to gain access to both its large DNA database and its clinical genomics software).

72. Raw data itself cannot be protected as intellectual property in the United States. *See* Daniel J. Gervais, *The Protection of Databases*, 82 CHI.-KENT L. REV. 1109, 1133–48 (2007) (discussing several failed bills introduced in Congress in the late 1990s and early 2000s to create sui generis intellectual property in data); J.H. Reichman & Pamuela Samuelson, *Intellectual Property Rights in Data?*, 50 VAND. L. REV. 51, 95–113 (1997) (discussing efforts to pass a database protection bill in the United States in the midst of expanding international protection for databases).

73. Mayo Collaborative Servs. v. Prometheus Labs., 132 S. Ct. 1289, 1294 (2012) (stating that if a claim recites "an 'inventive concept,' sufficient to ensure that the patent in practice amounts to

nonprecedential Federal Circuit decisions suggest that those seeking to patent computer-aided medical methods face significant § 101 hurdles.[74] The precise ways in which these hurdles become defined will affect the future trajectory of personalized medicine.

Kevin Collins suggests that the law-of-nature doctrine should be construed to deny the patentability of *propositional knowledge of* natural laws rather than natural laws themselves.[75] Yet in genomics research, as in much modern research, often the generation of propositional knowledge is the most difficult, labor-intensive step in research and development (R&D).[76] Once observed phenomena are comprehended and that understanding is codified, the step of putting such knowledge to practical use may be relatively trivial.[77] Hence the Supreme Court's recent jurisprudence is shifting the zone of patent eligibility away from a major locus of innovation in personalized medicine. The ramifications of this shift will depend on how it changes the interplay between patents, secrecy, and the public domain.

II. APPROPRIATION, COOPERATION, AND THE NEW GENOMIC COMMONS

A. Changing Dynamics Between Patents and Secrecy

Myriad rests on the theory that foreclosing patent eligibility for certain types of genomic information preserves a vibrant public domain.[78] But it would be a mistake to uncritically assume that new § 101 restrictions applied to genes and diagnostic methods will expand the storehouse of knowledge by increasing the

significantly more than a patent upon the natural law itself," then the claim describes a patentable application of a law of nature) (quoting Parker v. Flook, 437 U.S. 584, 594 (1978)).

74. *See, e.g.*, SmartGene, Inc. v. Advanced Biological Labs., SA, No. 2013-1186, 2014 WL 25924 (Fed. Cir. Jan. 24, 2014) (holding, in an unpublished opinion, that a claim to the use of a computer to select treatment for a patient recites an unpatentable abstract idea); PerkinElmer, Inc. v. Intema Ltd., No. 2011-1577, 2012 U.S. App. LEXIS 23845, at *68 (Fed. Cir. Nov. 20, 2012), *cert. denied*, 134 S. Ct. 102 (2013) (denying petition for certiorari to review nonprecedential Federal Circuit decision that diagnostic claims on a method to determine fetal risk of Down syndrome based on measuring two different biomarkers at two different times were patent ineligible because they did not meet the *Mayo* "inventive concept" standard); *see also* Ariosa Diagnostics, Inc. v. Sequenom, Inc., 788 F.3d 1371 (Fed. Cir. 2015) (affirming a district court ruling that claims on a noninvasive test to screen for fetal genetic abnormalities are patent-ineligible).

75. Collins, *supra* note 23, at 1337–38.

76. Brief of Professors Peter S. Menell & Jeffrey A. Lefstin as Amici Curiae in Support of Respondents at 11, Alice Corp. v. CLS Bank Int'l, 134 S. Ct. 2347 (2014) ("Doctrines that treat conventional application of even newly discovered computer algorithms, molecular pathways, and chemical synthesis as unpatentable threaten to exclude much of the inventive thrust of modern research.").

77. *See generally* Dan L. Burk, *The Role of Patent Law in Knowledge Codification*, 23 BERKELEY TECH. L.J. 1009 (2008) (explaining the patent system's role in incenting the formal codification of knowledge that is embodied in human memory).

78. Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 133 S. Ct. 2107, 2116 (2013) (explaining that without the judicially created patent-eligibility exceptions "the basic tools of scientific and technological work" would be tied up and "thereby inhibit future innovation premised upon them.").

number of donations to the genomic commons.[79] If their discoveries are not patent eligible, inventors face choices between contributing them to the public domain, legally protecting them as trade secrets, and relying on physical means (e.g., passwords and encryption) to control access and use. A central goal of the patent system is to accelerate the dissemination of socially valuable information, and one of the main rationales for awarding patents is that it spurs inventors to disclose knowledge to the public that they might otherwise elect to keep hidden.[80] Absent patent protection, inventors generally will seek alternative means to appropriate the value of their inventions. *Myriad*'s ultimate effects on the information commons therefore will depend on how the decision alters the dynamics between patents and secrecy.

Where patents are available, inventors often use them in combination with secrecy to appropriate different aspects of their discoveries. Myriad's business practices illustrate how patents can be leveraged to amass valuable related trade secrets. The company invested $500 million to develop a proprietary database of BRCA1/2 variants that it identified during the course of selling its patent-protected testing services.[81] Beginning in late 2004, Myriad chose to withhold from researchers new information about clinically significant genetic mutations that it had discovered.[82] These trade secrets have enabled Myriad to retain its dominant position in the BRCA1/2 clinical testing market despite the invalidation of some of its patent claims.[83] Due to the information that it has accumulated in

79. *See* Rochelle Cooper Dreyfuss, *Does IP Need IP? Accommodating Intellectual Production Outside the Intellectual Property Paradigm*, 31 CARDOZO L. REV. 1437, 1462 (2010) ("Were intellectual property laws abolished, intellectual products would not necessarily end up in a publicly-accessible domain, for control over information can often be retained in other ways.").

80. Collins, *supra* note 23, at 1315–16 ("The inventor gets exclusive rights for a limited period of time, and, in return, the public gets the benefit of access to the knowledge about the invention disclosed in the patent specification—knowledge that, absent patent disclosure, might have remained secret."). *See generally* Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590 (2011).

81. Gina Kolata, *DNA Project Aims to Make Public a Company's Data on Cancer Genes*, N.Y. TIMES, Apr. 13, 2013, at A14 ("With 17 years of experience, millions of tests looking for thousands of mutations in the [BRCA] genes, and a $500 million investment, the company was able to amass a huge database that tells which DNA changes increase cancer risk and by how much, and which are inconsequential blips in DNA.").

82. Robert Cook-Deegan et al., *The Next Controversy in Genetic Testing: Clinical Data as Trade Secrets?*, 21 EUR. J. HUM. GENETICS 585, 586 (2012) (explaining that Myriad adopted a deliberate policy to retain BRCA-related data as trade secrets and that it published articles on VUS results after November 2004 but did not disclose underlying sequence data or analytic algorithms); Sharon Levy, *Our Shared Code: The* Myriad *Decision and the Future of Genetic Research*, 121 ENVTL. HEALTH PERSP. A250, A253 (2013).

83. After the Supreme Court's 2013 decision, Myriad continued to assert several BRCA-related patent claims that were unaffected by the Court's ruling. *See, e.g.*, Olivia Pulsinelli, *Settlement Reached in Myriad Genetics' Patent Dispute With Houston Company*, HOUS. BUS. J. (Feb. 11, 2014, 9:02 AM), http://www.bizjournals.com/houston/news/2014/02/11/settlement-reached-in-myriad-genetics-patent.html [http://perma.cc/3JLZ-LGA9]. In January 2015, Myriad announced that it had settled or was in the process of settling patent infringement lawsuits that it had filed against companies offering genetic testing services. *See* Andrew Pollack, *Myriad Genetics Ending Patent Dispute on Breast Cancer Risk*

its proprietary database, according to Myriad only three percent of its analyses are returned with a diagnosis of "variant of unknown significance" (VUS), compared to twenty percent for most European laboratories.[84] To secure its competitive advantage, Myriad has negotiated contracts with several U.S. health plans that have agreed to protect its trade secrets.[85]

Myriad can exclude its proprietary database indefinitely, independent of any loss of patent protection for claimed sequences and methods. Consequently, the Supreme Court's ruling that Myriad's claimed isolated DNA is patent ineligible likely yields no immediate clinical benefits for patients diagnosed with a VUS. To illustrate, one of the named plaintiffs in the *Myriad* litigation who had obtained BRCA testing through Myriad and had been informed that she had a VUS sued on the theory that Myriad's patents prevented her from undergoing another test by an alternative provider.[86] Yet such a patient who receives a VUS result from Myriad today likely will receive the same result from a competing testing facility.

In order to break Myriad's market dominance, a consortium of medical professionals, researchers, and advocacy organizations have launched *Free the Data*, a collective effort to reconstruct Myriad's database whereby patients submit to a public database the results that they obtain from Myriad.[87] A software company has provided the infrastructure to enable data visualization and interpretation.[88] But until Myriad's proprietary data and interpretive algorithms are re-created in publicly accessible forms, competing testing services with VUS results will either have to pay Myriad to analyze their samples using its proprietary technology or deliver clinically unhelpful information to patients.

Myriad's actions demonstrate how gene patent holders can use their patents to accumulate and keep hidden additional proprietary genomic data. Yet, eliminating patents on genomic inventions could result in less, not more, publicly accessible information. Heightened patent-eligibility requirements might cause inventors to rely more heavily on secrecy to protect their patent-ineligible discoveries. Indeed, Myriad likely adopted its data nondisclosure policy in part to maintain its competitive advantage in anticipation of losing patent protection

---

Testing, N.Y. TIMES (Jan. 27, 2015), http://www.nytimes.com/2015/01/28/business/myriad-genetics-ending-patent-dispute-on-breast-cancer-risk-testing.html ("Myriad Genetics has essentially given up trying to stop other companies from offering tests for increased risk of breast cancer, ending a dispute that was the subject of a landmark Supreme Court ruling that human genes cannot be patented.").

84. Levy, *supra* note 82, at A253.

85. *Id.*

86. Ass'n for Molecular Pathology v. USPTO, 702 F. Supp. 2d 181, 189 (S.D.N.Y. 2010).

87. *See* Kolata, *supra* note 81, at A14 (noting that the "task is huge because the amount of data needed is vast" and that the project had reproduced only about 1.5% of the information in Myriad's database); FREE THE DATA, http://www.free-the-data.org/learn [http://perma.cc/Z3VJ-AKS7] (last visited Aug. 18, 2015).

88. Press Release, *Syapse Joins Free the Data! Initiative and Provides Software to Power Participant-centric Hereditary Gene Mutation Database*, REUTERS (July 30, 2013, 6:00 AM), http://www.reuters.com/article/2013/07/30/ca-syapse-idUSnBw305075a+100+BSW20130730 [http://perma.cc/9D2V-HJK2].

(through expiration, if not invalidation) for its BRCA testing services. Exclusion costs vary for different types of information, and rational actors will rely on secrecy to protect their information assets only when the private benefits of doing so outweigh the private costs. Such costs include direct fencing costs of taking security precautions as well as indirect opportunity costs associated with foregoing sharing and transacting with others.[89]

B. Implications for Sharing Regimes

As genomics research moves from a focus on individual disease-associated genes to the interrogation of big genomic data, progress will require both the creation of comprehensive data sets and the development of computational algorithms to analyze them. The combined effects of the elimination of technical barriers to whole genome sequencing and restrictions on patenting DNA and diagnostic methods will lead commercial diagnostics companies to compete based on their ability to aggregate and interpret complex data and to convey results to patients and physicians. Extensive, publicly available information about genetic links to disease could elevate the quality of and improve the terms of access to proprietary technologies by raising the benchmarks for success in the market.[90] The policy challenge is to develop a legal framework that fosters data sharing among disparate parties that are not bound by strong reciprocity norms. This will require coordinating an array of interdependent public and private interests in genomic information.[91]

The *Myriad* Court's removal of isolated DNA sequences from patent eligibility makes sense from an economic standpoint in light of the plummeting cost to sequence genes.[92] However, deciphering the molecular basis of disease also involves the expenditure of costly rival inputs of human labor.[93] The Supreme

89. *See* ROBERT P. MERGES, PETER S. MENELL & MARK A. LEMLEY, INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE 55–56 (6th ed. 2012).

90. *See* Rebecca S. Eisenberg & Richard R. Nelson, *Public vs. Proprietary Science: A Fruitful Tension?*, 131 DAEDALUS 89, 99 (2002) (noting that freely available data from the Human Genome Project improved the completeness of and terms of access to proprietary databases by setting benchmarks for commercial firms to exceed in order to attract paying customers).

91. *See* PRESIDENT'S COUNCIL OF ADVISORS ON SCI. & TECH., PRIORITIES FOR PERSONALIZED MEDICINE 2 (2008) ("To correct this imbalance between discovery and validation [of genetic markers], public and private sector research will need to be coordinated and prioritized more effectively, and the tools required for validation studies will need to be strengthened.").

92. *See* INST. OF MED. OF THE NAT'L ACADS., IMPROVING THE EFFICIENCY AND EFFECTIVENESS OF GENOMIC SCIENCE TRANSLATION: WORKSHOP SUMMARY 29 (2014), http://www.nap.edu/catalog.php?record_id=18549 [http://perma.cc/6VR6-YSC7] ("Within 10 years, the cost of a complete genome sequence will be less than the price of a single genetic test today.").

93. *See* Elain R. Mardis, *The $1,000 Genome, the $100,000 Analysis?*, 2 GENOME MED. 84 (2010), http://genomemedicine.com/content/2/11/84 [http://perma.cc/5EV4-F4L7] (noting that turning raw sequence data into useful clinical information requires "molecular and computational biologists, geneticists, pathologists and physicians with exquisite knowledge of the disease and of treatment modalities, research nurses, genetic counselors, and IT and systems support specialists, among others").

Court did not adequately consider the potential implications of more expansive applications of the product-of-nature and law-of-nature doctrines for large-scale, multi-institutional genomics research. Organizations motivated by communal norms, reputational rewards, and other nonmonetary incentives may freely share information regardless of financial payoffs. But other research entities, particularly those that make significant private investments in R&D, will do so only if they are convinced that it is worth gaining access to a broader universe of data. If they lack a mechanism to capture the value of their discoveries, institutions might have insufficient incentives to produce and disclose information outputs.[94]

A person's genome is a resource with strong network effects that make it the antithesis of a rival good—its value *increases* with use. Researchers expect that millions of people will have their genomes sequenced over the next several years.[95] The more DNA that is sequenced and analyzed, and the more data that is generated and shared, the more clinically meaningful genomic information will become. Networked computing makes it possible for multiple contributors to coordinate their efforts and produce highly complex work.[96] Genomics research therefore could evolve into a "comedy of the commons" in which greater participation leads to exponentially increasing social returns.[97] But without structured commitments among research institutions, medical centers, and diagnostics companies to standardize and deposit collected data into a centralized repository, a potential treasure trove of information could become irrevocably fragmented into proprietary silos.[98]

Cooperative data sharing must traverse a semicommons of overlapping and interacting common- and private-property regimes.[99] Henry Smith explains that,

---

94. *See* Henry E. Smith, *Toward an Economic Theory of Property in Information*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW 104 (Kenneth Ayotte & Henry E. Smith eds., 2011) (noting that intellectual property rights enable inventors to appropriate rival inputs used to discover and commercialize information).

95. *See* Leroy Hood & Mauricio Flores, *A Personal View on Systems Medicine and the Emergence of Proactive P4 Medicine: Predictive, Preventive, Personalized and Participatory*, 29 NEW BIOTECHNOLOGY 613, 617 (2012) ("In 10 years, everyone will have his or her genome sequenced."); *id.* at 615 fig.1 ("In 10 years a virtual cloud of billions of data points will surround each patient.").

96. Yochai Benkler, *Coase's Penguin, or, Linux and* The Nature of the Firm, 112 YALE L.J. 369, 378 (2002) (showing how the Internet makes it possible for peer-production open innovation projects to develop and thrive).

97. *See* Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. CHI. L. REV. 711, 768–70 (1986) (explaining that a "comedy of the commons" arises where social value increases with greater use of a resource).

98. *See, e.g.*, Erika Check Hayden, *Geneticists Push for Global Data-sharing,* 498 NATURE 16, 16 (2013) (describing a global alliance involving the NIH and several medical, research, and advocacy organizations to create publicly available databases of genomic and clinical information but noting that "[a] big question for the group is whether it can convince institutions to share their most meaningful data").

99. *See* Smith, *supra* note 94, at 114 ("In a semicommons, private and common property regimes overlap and interact."); *see also* Robert A. Heverly, *The Information Semicommons*, 18 BERKELEY TECH. L.J. 1127, 1130–31 (2003) ("Information ownership can better be described as a

"[i]n a semicommons, a resource is owned and used in common for one major purpose, but, with respect to some other major purpose, individual economic units—individuals, families, or firms—have property rights to separate pieces of the commons."[100] Across the biomedical research landscape, information and tools are used at different scales to simultaneously advance public science and further commercial activities. Academic scientists form a limited-membership knowledge community loosely bound together by norms of reciprocity.[101] This "sharing core" of innovation is surrounded by a jagged "property perimeter" of legal and extralegal access restrictions that support the development of commercial products and services.[102]

Though tempered by professional norms of communalism and disinterestedness, members of the academic knowledge community routinely engage in proprietary practices in attempts to gain competitive advantages. Individual scientists often disregard their universities' formal property rights in order to obtain mutual benefits from the exchange of proprietary resources.[103] But while they usually refrain from enforcing formal property rights against each other, academic scientists frequently assert informal property rights through the use of secrecy and access restrictions.[104] For example, a scientist may delay sharing manuscripts and research tools in order to "stake a claim" to a research project in progress.[105] Such efforts to enforce proprietary rights in research discoveries are evident in policies that evolved to govern publicly supported gene sequencing projects, in which data users were temporarily prohibited or discouraged from using newly discovered data in order to preserve data generators' rights to first publication.[106]

Collateral revenue streams, including federal grants, corporate sponsored

---

semicommons, a form of ownership that acknowledges the dynamic relationship between private and common uses.").

100. Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131, 131–32 (2000).

101. *See* Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, 13 SOC. PHIL. & POL'Y 145, 146 (1996) (noting that traditional science is "more analogous in some ways to a limited-membership, shared-access common area than a truly wide-open, *unclaimed* space").

102. *See* Jonathan M. Barnett, *The Illusion of the Commons*, 25 BERKELEY TECH. L.J. 1751, 1756–57 (2010) (arguing that innovation markets generally encompass a "sharing core" and a "property perimeter").

103. Katherine J. Strandburg, *User Innovator Community Norms: At the Boundary Between Academic and Industry Research*, 77 FORDHAM L. REV. 2237, 2238 (2009) ("Traditional practices of sharing research tools and materials in the academy . . . can be viewed as examples of free revealing in user innovator communities.").

104. Merges, *supra* note 101, at 150–51 ("[F]ew scientists see the debate in polar terms—as a simple choice between the total absence of property rights (or their equivalent) and the wholesale adoption of strong, formal property rights (in the form of patents).").

105. *Id.* at 148–49 (citing WARREN O. HAGSTROM, THE SCIENTIFIC COMMUNITY 87, 91 (1965)).

106. *See* Jorge L. Contreras, *Constructing the Genome Commons*, *in* GOVERNING KNOWLEDGE COMMONS 99, 116–20 (Brett M. Frischmann et al. eds., 2014) (documenting various policies that were developed to secure periods of exclusive use for data generators).

research, and technology licensing revenues, finance the academic science commons.[107] University scientists generally follow traditional norms of open discourse when communicating with noncompetitor peers but expressly rely on formal property rights when transacting with commercial developers.[108] Notably, since even nominally "pure" science could have future commercial value, scientists interact with peers with an eye toward potential product development opportunities.[109] Many individuals operate both within and without the sharing core, such as academic researchers who spin off companies. Also, different parts of universities have different missions and thus conflicting interests with respect to uses of proprietary information. For example, technology transfer offices aim to monetize university scientists' discoveries, while clinical testing facilities housed in academic medical centers seek free access to proprietary research results for (commercial) patient use.[110]

The variety of cooperative arrangements that have been developed to support technological innovation illustrates the wide range of possibilities for combining private and common property schemes. Resource sharing arrangements can be structured in a number of ways between open, unrestricted access on one end and a closed, proprietary model on the other. Newly created information may be unconditionally donated to the commons, or creators may welcome all comers but limit them to a defined set of privileged uses.[111] Alternatively, members of a defined group can form a "limited commons" to collectively control shared resources and exclude nonmembers.[112] Some "open science" projects coordinate collaborative research through private ordering of shared IP rights rather than directly depositing results into the public domain.[113] And many commercial firms appropriate the value of their inventions by using hybrid private-collective action models of innovation.[114] For example, software

107. Barnett, *supra* note 102, at 1803–04.

108. Merges, *supra* note 101, at 163 (noting that scientists "divid[e] potential transactions into two classes: those with other pure scientists . . . and those with commercial entities").

109. *See id.* at 167 ("[W]hat is pure [science] today may have commercial potential tomorrow.").

110. Robert Cook-Deegan et al., Commentary, *The Dangers of Diagnostic Monopolies*, 458 NATURE 405, 406 (2009), http://www.nature.com/nature/journal/v458/n7237/pdf/458405a.pdf [http://perma.cc/8UB6-GNRM].

111. *See* Heverly, *supra* note 99, at 1146 (explaining that there is no uniform definition of the public domain).

112. *Id.* at 1155; Carol M. Rose, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems*, 83 MINN. L. REV. 129, 132 (1998) ("[P]roperty held as a commons among the members of a group, but exclusively vis-à-vis the outside world."); *see also* Hanoch Dagan & Michael A. Heller, *The Liberal Commons*, 110 YALE L.J. 549, 557 (2001) (distinguishing between open access and common property regimes).

113. Robin Feldman & Kris Nelson, *Open Source, Open Access, and Open Transfer: Market Approaches to Research Bottlenecks*, 7 NW. J. TECH. & INTELL. PROP. 14, 25 (2008) (noting that several Open Science projects copied the Open Source Software licensing approach and use patents to ensure that project innovations remain openly available).

114. *See* Eric von Hippel & Georg von Krogh, *Open Innovation and the Private-Collective Model for Innovation Incentives*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF

companies utilize open-source platforms in addition to selling proprietary "software as a service" and conventional licensed products. The most successful open source projects, such as the operating system Linux, have received considerable support from IBM and other firms that develop proprietary technologies that run on the platform.[115]

Sharing arrangements thrive in small, close-knit groups of similarly skilled individuals engaged in activities that require little capital investment and produce outputs of low economic value.[116] But as innovation environments grow larger and more heterogeneous, exclusionary instruments may become necessary to regulate access and prevent unraveling.[117] Property can sustain cooperative innovation by structuring an interface between information production within a commons and its commercial exploitation beyond the commons.[118] However, projects that span across shared and private spaces work effectively only when interfaces are easily navigable and proprietary interests do not crowd out open development.[119]

Cooperative innovation in genomics research requires combining formal property rights and informal sharing arrangements in a manner that promotes cross-institutional exchanges.[120] Heightened patent-eligibility requirements could diminish information flows by making it more onerous for researchers to obtain access to others' patent-ineligible discoveries. When technology is patented, the burden of inertia is on the property owner to prevent unauthorized use of disclosed inventions. In contrast, when unpatented proprietary information is shielded, the burden is on the user to gain access to the restricted resource.[121] But possible losses to the commons stemming from greater reliance on secrecy inherently are limited to information that is practically excludable because it is not

---

CONTEMPORARY RESEARCH 201, 203 (Rochelle C. Dreyfuss & Katherine J. Strandburg eds., 2011) (explaining how innovators can maximize profits by openly revealing proprietary information).

115. *See* Barnett, *supra* note 102, at 1810 ("It is hard to underestimate the contribution—both in terms of cash, code and, most importantly, personnel—made by proprietary software companies to facilitate the development and adoption of open source's largest successes to date."); *see also* Ronald J. Mann, *Commercializing Open Source Software: Do Property Rights Still Matter?*, 20 HARV. J. L. & TECH. 1, 11–13 (2006).

116. Barnett, *supra* note 102, at 1770.

117. *Id.* at 1757.

118. *See* Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements in Information*, 116 YALE L.J. 1742, 1751–61 (2007) (theorizing that intellectual property can facilitate team production by supporting a modular system of allocating resources to create, use, and commercialize information).

119. Dreyfuss, *supra* note 79, at 1438 (noting that a dual regime may be hard to maintain where proprietary rights holders crowd out norms of openness or sue open developers for infringement).

120. *See* Smith, *supra* note 94, at 138–42 (explaining that a semicommons only works if the benefits of combining private and common uses outweigh the costs associated with strategic behavior).

121. Rebecca S. Eisenberg, *Noncompliance, Nonenforcement, Nonproblem? Rethinking the Anticommons in Biomedical Research*, 45 HOUS. L. REV. 1059, 1062 (2008) ("[T]he burden of inertia matters in determining the practical impact of transaction costs associated with property rights.").

self-disclosing when exploited.[122] For academic scientists (and to a lesser extent commercial entities seeking to signal the importance of their work), the need to publish scientific research for career advancement purposes means that exploitation necessarily entails a certain amount of information disclosure.

Trade secrecy might, in some circumstances, be a better legal mechanism than patents to facilitate sharing of genomics research. Paradoxically, trade secrecy can promote information dissemination by serving as a less costly and more porous substitute for legal and physical barriers that inventors might otherwise erect to prevent competitors from acquiring proprietary information.[123] Under the Uniformed Trade Secrets Act (UTSA), information must satisfy four criteria to be legally protectable: (1) it is capable of adding economic value to the holder; (2) it is not generally known; (3) it is not readily ascertainable by proper means; and (4) the holder has taken reasonable precautions to prevent its disclosure.[124] Unlike patents, trade secrecy does not protect against independent creation and reverse engineering by others.[125] And courts generally interpret the reasonable-precautions requirement to allow trade secret holders to market products incorporating the secret or to make targeted, confidential disclosures to others in order to appropriate its value.[126]

Trade secret law fosters collaboration by inferring a confidential relationship from circumstances in which the trade secret holder otherwise would be unwilling to share.[127] But the efficient exchange of trade secrets requires trust.[128] Parties may be reluctant to enter into transactions involving the exchange of information that cannot be evaluated prior to its disclosure.[129] Where trust between the parties is lacking, patents generally serve as more efficient vehicles for knowledge transfers.[130] Hence restrictions on patenting could make knowledge transfers

122. *See* Katherine J. Strandburg, *What Does the Public Get? Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 104–18 (2004) (drawing a distinction between self-disclosing and non-self-disclosing inventions in regard to patent law's experimental use exception).

123. *See* Mark A. Lemley, *The Surprising Virtues of Treating Trade Secrets as IP Rights*, 61 STAN. L. REV. 311, 332–37 (2008) (explaining how trade secrecy creates incentives to disclose and use information).

124. *See* ROBERT P. MERGES, PETER S. MENELL & MARK A. LEMLEY, INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE 36–37 (6th ed. 2012).

125. *See* Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 482–85 (1974) (suggesting that inventors of patentable inventions will not opt for the weaker protection afforded by trade secrecy).

126. *See, e.g.*, Metallurgical Indus., Inc. v. Fourtek, Inc., 790 F.2d 1195, 1200–01 (5th Cir. 1986).

127. Lemley, *supra* note 123, at 336–37.

128. *See* Geertrui Van Overwalle, *Uncorking Trade Secrets: Sparking the Interaction Between Trade Secrecy and Open Biotechnology*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF CONTEMPORARY RESEARCH, *supra* note 114, at 246, 264.

129. Dan L. Burk & Brett H. McDonnell, *The Goldilocks Hypothesis: Balancing Intellectual Property Rights at the Boundary of the Firm*, 2007 U. ILL. L. REV. 575, 585 (2007) (explaining that trade secrecy does not fully solve disclosure problems where potential licensees worry that confidential information is not useful or is available from public sources).

130. *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 476–77 (2005) (noting that patent law lowers transaction costs compared to trade secrecy and contract law by

among parties that lack established trust relationships more costly. If the costs of relying on legal protections to prevent misappropriation of unpatentable proprietary information are too high, such parties might opt for absolute secrecy and eschew collaboration.

With some types of information, trade secrecy effectively establishes boundaries between public and proprietary spaces outside of established trust relationships. This occurs where the trade-secret owner can deploy its technology for use by others and still maintain its competitive advantage. For example, Google protects its search algorithms as trade secrets, but search results and the information to which they link are public resources that are freely available to anyone for any purpose.[131] Google profits from revenues derived from Internet advertising while simultaneously enriching the information commons.

But Myriad's decision to withhold its BRCA1/2 variant data from researchers demonstrates that there are limits to relying on selective disclosure to sustain a mutually beneficial sharing arrangement among heterogeneous groups of users. Throughout the period of its patent protection, Myriad has consistently encouraged basic researchers to investigate the BRCA1/2 genes even as it aggressively asserts its patent rights against competing clinical laboratories. The company has freely permitted scientists to conduct and publish thousands of research studies on BRCA1 and BRCA2.[132] Myriad contends that it stopped sharing its variant data with researchers in 2004 because it was concerned that the data were being misused to disseminate clinically invalid information to patients.[133] While Myriad might have been genuinely concerned that patients were receiving misinformation about BRCA mutations, a more hard-nosed take is that Myriad adopted its nondisclosure policy when it realized that the data were being used in a way that threatened its commercial interests. Since there was no easy way for the company to limit use of its proprietary data to noncommercial research purposes, Myriad opted to withhold it entirely.

---

establishing a title registration system for information assets); Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477, 1500–04 (2005) (explaining why patent law works better than trade secret law to facilitate disclosures between parties negotiating arms-length contracts).

131. Michael J. Madison, *Open Secrets*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF CONTEMPORARY RESEARCH, *supra* note 114, at 222, 240–43.

132. Ass'n for Molecular Pathology v. USPTO, 702 F. Supp. 2d 181, 210 (S.D.N.Y. 2010); *see also* Ass'n for Molecular Pathology v. USPTO, 689 F.3d 1303, 1315 (Fed. Cir. 2012) (explaining that Myriad's cease-and-desist notification to a clinical laboratory "did not apply to research testing 'for the purpose of furthering non-commercial research programs, the results of which are not provided to the patient and for which no money is received'"). Myriad's selective enforcement of its patents comports with the results of empirical studies showing that, despite widespread concerns, patents rarely block academic research. *See* Wesley M. Cohen & John P. Walsh, *Real Impediments to Academic Biomedical Research*, *in* 8 INNOVATION POL'Y & ECON. 1, 9–10 (Adam B. Jaffe et al. eds., 2008).

133. Kolata, *supra* note 81, at A14 (providing statement by Myriad representative asserting that the company stopped posting its data because it was concerned that it was being inappropriately used to make clinical diagnoses rather than for research purposes).

C. Common-Interest Tragedies in Genomics Research

Though the Supreme Court's *Myriad* opinion ostensibly resolves a long recognized anticommons problem created by gene patenting, the decision may in fact worsen a growing commons problem in genomics research. Rebecca Eisenberg and Michael Heller famously highlighted the "tragedy of the anticommons" that can result when too many fragmented IP rights in upstream biomedical discoveries impede innovation by making it unduly costly for developers to collect all the necessary licenses.[134] This concept has been construed as the converse of the tragedy of the commons that can occur when the absence of private property rights leads to either overuse or underproduction of socially valuable resources.[135] But, as Lee Anne Fennell observes, instead of being diametric opposites, the two tragedies actually merge together when taken to their logical conclusions.[136] Elucidating the fine line between commons and anticommons problems aids in understanding the complex ways in which the Supreme Court's patent-eligibility decisions may impact genomics research.

The interacting mixture of individually owned and commonly owned elements that characterizes a semicommons provides a lens through which to identify common interest tragedies.[137] The core scenario underlying both commons and anticommons tragedies is a resource system that must accommodate multiple uses and users.[138] Both types of situations require two threshold conditions: (1) individual members of a group do not fully internalize the costs and/or benefits of their uses of a resource; and (2) collective returns are higher in the case of cooperation than in the case of defection.[139] A commons problem exists where individuals fail to use a resource system in a socially productive way because private costs outweigh private benefits and individual users cannot sufficiently capture positive externalities.[140] An anticommons

134. Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 698–99 (1998). The issue of whether an anticommons actually has emerged in biomedical research has been hotly contested. *See* Matthew Herder, *Patents & the Progress of Personalized Medicine: Biomarkers Research as Lens*, 18 ANNALS HEALTH L. 187, 210–14 (2009) (concluding that "the empirical evidence amassed thus far is mixed").

135. Commons tragedies can stem from overuse of a commonly shared rival resource, as typified by Garrett Hardin's example of overgrazing a common field. *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968). With nonrival information resources, the crux of the problem is not overuse and negative externalities but rather underuse and positive externalities. *See, e.g.*, ELINOR OSTROM ET AL., RULES, GAMES, AND COMMON-POOL RESOURCES 14–15 (1994) (discussing problems of underproduction as well as problems of overuse).

136. Lee Anne Fennell, *Common Interest Tragedies*, 98 NW. U.L. REV. 907, 909 (2004) ("Indeed, a potential anticommons problem stands between every garden-variety commons tragedy and its solution.").

137. Lee Anne Fennell, *Commons, Anticommons, Semicommons*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW, *supra* note 94, at 35, 47–48 (explaining that the semicommons is less a distinctive property type than a lens or frame through which to view incentive misalignments produced by differently scaled activities under different ownership regimes).

138. *See id.* at 35–42.

139. Fennell, *supra* note 136, at 929.

140. *Id.* at 929–30.

problem exists where the private benefits of using a resource system in a socially productive way exceed the private costs, but individuals hold out in the hopes of obtaining a disproportionately large surplus.[141]

The two tragedies roughly correspond to two strategic templates in game theory: the commons problem resembles the Prisoner's Dilemma and the anticommons problem resembles the Chicken Game.[142] The Prisoner's Dilemma describes how *blindered* decision making can lead to socially suboptimal results when the payoffs for the players are highest when everyone cooperates, but the players cannot coordinate their actions.[143] In order to avoid a "sucker's payoff," each player improves his or her personal payoff by defecting.[144] The Chicken Game describes *bluffing* situations in which each player is made better off by cooperating, but the players maximize their personal payoffs by holding out and allowing someone else to incur a cost or take a smaller share of the resulting surplus.[145] If the bluffing is unsuccessful and all players hold out, everyone ends up worse off than they would have been had they agreed to cooperate.[146] The key difference between the two strategic games is that, in the Prisoner's Dilemma, uncoordinated players always prefer to defect, while in the Chicken Game, the players' choices depend on what they think the other players will do. Cooperation failure is the worst possible outcome of the Chicken Game, so players who believe that others will strategically hold out may opt to cooperate in exchange for a disproportionally small share of the surplus.[147]

Both types of common interest tragedies can be averted through legal rules and state regulations, or through informal norms that constrain strategic behavior.[148] Recalibrating property rights can resolve tragedies by changing the private payoffs associated with socially productive behavior. For example, the state can subsidize cooperation at a level that allows actors to internalize previously externalized benefits.[149] Alternatively, norm-based sanctions and rewards, such as shaming and accolades, can alter perceived payoffs by compelling community members to internalize the negative and positive externalities associated with their behavior.[150]

But interventions designed to eliminate one kind of common interest tragedy risk the creation of another where different affected parties value the uses of

141. *Id.* at 954–55 (illustrating the distinction using as an example the problem of replacing a burnt-out light bulb in a community laundry room).

142. *Id.* at 941–42.

143. *Id.* at 953.

144. *Id.* at 945.

145. *Id.* at 947–49.

146. *Id.* at 946–47.

147. *Id.* at 947–48.

148. *Id.* at 912–13.

149. Fennell, *supra* note 137, at 40.

150. Fennell, *supra* note 136, at 961–62 (explaining how strong cooperative norms can make players behave as if they are in an Assurance Game interaction (involving a strategy of joint cooperation), even where the pecuniary payoffs are structured as a Prisoner's Dilemma).

common resources differently and can hide their true preferences from each other.[151] For example, a rule that aims to solve a commons problem by granting individuals rights to prevent others from farming might lead to an anticommons problem if a would-be farmer would get tremendous value from farming and an indifferent neighbor withholds permission in hopes of extracting a disproportionately large share of the surplus. Heterogeneous communities also may produce complex strategic dynamics where, for example, some players confront a Prisoner's Dilemma while others are more sensitive to reciprocity norms and are willing to cooperate regardless of personal payoffs.[152]

Framing commons and anticommons tragedies as collective action problems sheds light on how shifting patent-eligibility standards might impact incentives for genomics researchers to engage in socially productive sharing behavior. The genome is a resource system with a varied array of uses and users. Gene patents issued in the early days of genomics research averted a tragedy of the commons that might have arisen had researchers been unable to recoup the then-substantial investment of money and effort required to identify genes, determine their functions, and develop commercial products based on that information. However, as the costs to discover genes fell in the years leading up to *Myriad*, commentators became increasingly concerned that patents in gene sequences were creating an anticommons tragedy by enabling individual patentees to hold out for a disproportionately large share of the surplus that would result if information fragments were assembled together.[153] *Myriad* eliminated this concern in holding that isolated gene sequences no longer can be privately owned. But heightened uncertainty surrounding the patentability of complex, data-driven genomic discoveries now threatens to undermine socially productive sharing regimes by altering the private payoffs associated with cooperation.

Misconstruing clinical associations drawn from aggregate recorded data as patent-ineligible natural laws risks replacing a perceived anticommons problem (Chicken Game) with a commons problem (Prisoner's Dilemma). Information is nonrivalrous and thus cannot be depleted by overuse in the same way that finite tangible resources can.[154] However, a tragedy of the commons can occur with respect to information resource production where individuals have insufficient incentives to invest their privately owned labor and tools into R&D and to disclose their results.[155] Even if researchers attribute the highest value to cooperation, the fear that others will defect by withholding meaningful information could compel players to defect in order to avoid the sucker's payoff.

151. *Id.* at 948–49 (explaining how resolving a Prisoner's Dilemma can create a Chicken Game).

152. *Id.* at 963.

153. *See* Heller & Eisenberg, *supra* note 134, at 699.

154. Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031, 1050–51 (2005).

155. *See* Fennell, *supra* note 137, at 37–39 (noting that one's person or one's labor is a privately owned asset).

Multi-institutional alliances designed to foster genomic data sharing thus may falter absent a stabilizing structure that recalibrates private payoffs in favor of cooperation.

By way of analogy, imagine a room full of ciphers containing valuable information hidden away in a remote location. For many years the room is inaccessible because people lack the means to make a path to the front door. Eventually technology advances, a road is paved, and opening the front door becomes easy. Heterogeneous groups of people with different motivations eagerly trek to claim ownership of and decode the ciphers inside. However, cipher owners soon discover that their ciphers convey little meaning on their own and are actually pieces of an exponentially more complicated puzzle that can only be understood in combination with other ciphers stored in millions of other similar rooms.

At this point, revoking the property rights of current puzzle-piece owners may prevent potential anticommons problems that could occur if individuals were to hold out from contributing to the puzzle in hopes of extracting disproportionately large surpluses. But averting an anticommons tragedy might simultaneously create a commons tragedy by leaving individuals with insufficient incentives to coordinate their efforts to complete the puzzle and decode its meaning. Under this analogy, heightened patent-eligibility requirements and a corresponding turn toward secrecy risks exacerbating a commons problem in genomics research. Part III explains how, perhaps counterintuitively, FDA regulation might alleviate this problem by enabling researchers to internalize the benefits of disclosing their genomic discoveries.

III. THE POTENTIAL COORDINATING ROLE OF FDA REGULATION

Patent-eligibility hurdles for genomic inventions are rising against the backdrop of a shifting regulatory regime. New § 101 limitations coincide with calls to heighten regulation of diagnostic products.[156] Although the FDA has long refrained from regulating tests such as Myriad's BRCA1/2 screening panel, the agency in recent years has signaled its intent to significantly revamp its policy toward clinical diagnostics.[157] The obvious concern is that the combination of decreased ability to patent genomic discoveries and higher regulatory barriers to market entry could decimate the fledgling industry supporting personalized medicine. However, the FDA actually could promote innovation by using its market gatekeeping powers as a "visible hand" to coordinate genomics research.[158]

156. *See, e.g.*, George J. Annas & Sherman Elias, *23andMe and the FDA*, 370 NEW ENG. J. MED. 985 (2014), http://www.nejm.org/doi/full/10.1056/NEJMp1316367 [http://perma.cc/3HQJ-9ZC2].

157. *See infra* note 175 and accompanying text.

158. *See* Robert B. Ahdieh, *The Visible Hand: Coordination Functions of the Regulatory State*, 95 MINN. L. REV. 578, 602–03 (2010) ("[T]he entire universe of collection action failures—public goods problems, tragedies of the commons, and free riding, among other arguments for regulatory

A carefully crafted regulatory scheme may advance personalized medicine by rewarding the generation and dissemination of patent-ineligible genomic information.[159]

A. Heightened Scrutiny of Diagnostics

1. Laboratory-Developed Tests

The regulatory framework applied to diagnostic testing presently is in a state of considerable flux. The FDA and the Centers for Medicare and Medicaid Services (CMS) share overlapping regulatory authority over diagnostic testing facilities. Under the Clinical Laboratory Improvement Amendments of 1988 (CLIA), CMS (or another body acting on its behalf) must certify a clinical laboratory before it can receive human specimens for diagnostic testing.[160] Through this regime CMS ensures diagnostic tests' *analytical* validity, which "refers to a laboratory's ability to get the correct answer reliably over time, for example, to detect a genetic variation when it is present and *not* detect it when it is absent."[161] A test's *clinical* validity describes its capacity to diagnose or predict the risk of a particular disease or condition.[162] Analytical validity and clinical validity combine to measure the accuracy of a diagnostic test. Clinical utility is a separate term used to measure a test's usefulness in informing medical care and improving patient outcomes.[163]

Most genetic diagnostic tests currently offered by medical institutions and commercial firms lack demonstrated clinical validity and utility. Laboratories can reasonably ensure analytical validity by adhering to CLIA requirements and technical proficiency standards, but the capacity of such tests to improve patient care is largely unproven. Genetic tests used for diagnostic or treatment purposes obviously can cause great harm if offered without adequate assurance of clinical benefit. Policy debates center on the appropriate methods to show clinical utility

---

intervention—can be understood as stories of defection . . . . The prevention of such defection emerges as the key function of the regulatory state.").

159. *See* Rebecca S. Eisenberg, *The Role of the FDA in Innovation Policy*, 13 MICH. TELECOMM. & TECH. L. REV. 345, 347 (2007) (noting that the conventional view of FDA regulation fails to recognize the important role that regulation plays in promoting innovation by incenting the generation of credible information about medical products).

160. 42 C.F.R. § 493.1 (2015). CLIA does not apply to laboratories conducting tests only for research purposes or to laboratories in those states where state law establishes requirements of equal or greater stringency (currently, New York and Washington).

161. *At Home DNA Tests: Marketing Scam or Medical Breakthrough?: Hearing Before the S. Spec. Comm. on Aging*, 109th Cong. 3 (2006) (statement of Kathy Hudson, Dir. of Genetics & Pub. Pol'y Ctr. & Assoc. Professor of Berman Bioethics Inst., Inst. of Genetic Med. & Assoc. Professor of Dep't of Pediatrics Johns Hopkins Univ.).

162. FOOD & DRUG ADMIN., PAVING THE WAY FOR PERSONALIZED MEDICINE: FDA'S ROLE IN A NEW ERA OF MEDICAL PRODUCT DEVELOPMENT 29–30 (2013).

163. *Id.* at 30.

and the level of evidence—in terms of quantity, quality, and type—that should be obtained before introducing a new diagnostic test into routine medical practice.[164]

The FDA has authority to oversee diagnostic devices, but it is not clear what the FDA can and will do to regulate genetic diagnostic tests. Currently, many diagnostic tests are administered to patients without any FDA review. The agency considers *in vitro* diagnostics (IVDs),[165] including genetic tests, to be medical products within its regulatory jurisdiction.[166] However, unless manufacturers sell such tests to laboratories as "test kits"—in which case the manufacturers must obtain FDA clearance before marketing them—the FDA has historically declined to exercise its authority.[167] The agency's divergent treatment of test kits and laboratory-developed tests (LDTs, or "home brews"[168]) has pushed many clinical testing facilities to develop diagnostics in-house in order to avoid FDA scrutiny.[169] Under this business model, the testing facility does not commercially distribute a test kit but does commercially provide services derived from development and use of its LDT.[170]

Over the past several years the FDA has produced a series of documents conveying its plans to change this regulatory picture. In 2007, the agency published a draft guidance proposing to expand its oversight to a subset of LDTs termed *in vitro* diagnostic multivariate index assays (IVDMIAs), which apply complex algorithms to interpret multiple recorded variables.[171] One justification for the proposed regulatory expansion was that the algorithms used in IVDMIAs

164. J. Woodcock, *Assessing the Clinical Utility of Diagnostics Used in Drug Therapy*, 88 CLINICAL PHARMACOLOGY & THERAPEUTICS 765, 765 (2010).

165. IVDs are devices that are used in the laboratory analysis of human samples for diagnosis, screening, staging, and disease management. AMANDA K. SARATA & JUDITH A. JOHNSON, CONGRESSIONAL RESEARCH SERVICE, REGULATION OF CLINICAL TESTS: IN VITRO DIAGNOSTIC (IVD) DEVICES, LABORATORY DEVELOPED TESTS (LDTS), AND GENETIC TESTS 1 (2014).

166. *See* Medical Device Amendments of 1976, Pub. L. No. 94-295, 90 Stat. 539, 575 (1976).

167. *See* PRESIDENT'S COUNCIL OF ADVISORS ON SCI. & TECH., *supra* note 91, at 37.

168. *See* Alondra Nelson & Joan H. Robinson, *The Social Life of DTC Genetics: The Case of 23andMe*, *in* ROUTLEDGE HANDBOOK OF SCIENCE, TECHNOLOGY, AND SOCIETY 108, 116 (Daniel Lee Kleinman & Kelly Moore eds., 2014) ("LDTs are those test kits that are created and used completely in-house, and as such are sometimes called 'home brews.'").

169. *Id.* at 39 ("Based on [the] FDA's longstanding decision to exercise enforcement discretion with respect to [home brew tests] . . . a number of business plans were based on a path to market via laboratory-based implementation and CLIA regulation, rather than [a] path of a PMA submission to [the] FDA, which is perceived to be riskier and more costly.").

170. PRESIDENT'S COUNCIL OF ADVISORS ON SCI. & TECH., *supra* note 91, at 38–39.

171. Food & Drug Admin., Draft Guidance for Industry, Clinical Laboratories, and FDA Staff: In Vitro Diagnostic Multivariate Index Assays 5 (July 26, 2007) (unpublished guidance document), http://www.fda.gov/downloads/MedicalDevices/. . ./ucm071455.pdf [http://perma.cc/MA4E-FH4M] ("An IVDMIA is a device that: 1) [c]ombines the values of multiple variables using an interpretation function to yield a single, patient-specific result . . . that is intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment or prevention of disease, and 2) [p]rovides a result that is non-transparent and cannot be independently derived or verified by the end user.").

are often proprietary and test users cannot independently verify the results.[172] The draft guidance attracted intense industry criticism, and the agency never finalized it. Instead, in 2010, the FDA announced its intent to regulate all LDTs.[173]

In June 2013—incidentally, the same month that the Supreme Court issued its *Myriad* decision—the American Clinical Laboratory Association (ACLA) filed a citizen petition requesting that the FDA refrain from regulating LDTs as devices.[174] The ACLA maintains that LDTs are "proprietary procedures" and therefore not subject to regulation under the Federal Food, Drug, and Cosmetics Act (FFDCA).[175] Despite this contention, on October 3, 2014, the FDA issued a draft guidance that proposes a risk-based, phased-in framework for oversight of complex LDTs.[176] The agency intends to continue to refrain from regulating "traditional" LDTs that are manufactured and used by healthcare facilities for patients who are being treated within those facilities, employ legally marketed reagents and instruments, and can be interpreted by laboratory professionals without the use of interpretive software.[177] However, it plans to regulate moderate- and high-risk LDTs that rely on high-tech instrumentation and software to generate results and clinical interpretations.[178]

2. Direct-to-Consumer Services

Direct-to-consumer (DTC) genetic LDTs have been the subject of particular scrutiny because of concerns that consumers might overestimate their usefulness and reliability. DTC medical products and services can be ordered, reviewed, and shared by individuals without engaging a healthcare professional at any stage of the process. A 2006 Government Accountability Office (GAO) investigation of four companies selling DTC genetic tests found that these companies "misled consumers by providing test results that were both medically unproven and so ambiguous as to be meaningless."[179] In response to this investigation, the FDA, the U.S. Centers for Disease Control and Prevention, and the U.S. Federal Trade Commission issued a public warning to consumers to be wary of claims made by

172. C. Wilson et al., *Biomarker Development, Commercialization, and Regulation: Individualization of Medicine Lost in Translation*, 81 CLINICAL PHARMACOLOGY & THERAPEUTICS 153, 154 (2007).

173. Oversight of Laboratory Developed Tests, 75 Fed. Reg. 34,463 (June 17, 2010).

174. AMERICAN CLINICAL LABORATORY ASSOCIATION, CITIZEN PETITION 1 (2013).

175. *Id.* at 2.

176. Food & Drug Admin., Draft Guidance for Industry, Food and Drug Administration Staff, and Clinical Laboratories: Framework for Regulatory Oversight of Laboratory Developed Tests (LDTs) (Oct. 3, 2014) (unpublished guidance document), http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM416685.pdf [http://perma.cc/7A3V-KXMZ].

177. *Id.* at 21.

178. *Id.* at 12–14.

179. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-847T, DIRECT-TO-CONSUMER GENETIC TESTS: MISLEADING TEST RESULTS ARE FURTHER COMPLICATED BY DECEPTIVE MARKETING AND OTHER QUESTIONABLE PRACTICES 1–2 (2010).

DTC genetic testing companies.[180] A second GAO investigation conducted from June 2009 to June 2010 concluded that the reported test results of four different DTC genetic testing companies selected for being "frequently cited as being credible by the media and in scientific publications" were "misleading and of little or no practical use to consumers."[181]

The DTC genetic testing industry nonetheless flourished until 2010, when Pathway Genomics announced plans to partner with Walgreens and sell kits in drug stores nationwide.[182] This garnered the FDA's attention, and the agency responded by sending warning letters to several companies informing them of its intention to regulate DTC genetic tests as medical devices.[183] Recipients of warning letters included companies that used software programs to interpret sequence data generated by external laboratories.[184] Soon thereafter, many DTC genetic testing companies folded, and others changed their business models to require physician participation or narrowed their service offering to DNA sequencing without interpretation and analysis.[185]

Until recently, 23andMe dominated the health-related DTC genetic testing market.[186] But in November 2013 the FDA sent a warning letter to 23andMe instructing the company to discontinue marketing of its Personal Genome Service (PGS) until it receives FDA clearance for this test, a LDT that the FDA says meets the definition of a medical device under the FFDCA.[187] The agency chastised the company for ignoring its proposed labeling modifications and the analytical and clinical validity requirements that the FDA had established for 23andMe's disease-related claims.[188] The letter cited potential health consequences that could result from inaccurate health risk assessments, such as a false positive

180. *See* FED. TRADE COMM'N, CONSUMER INFORMATION: DIRECT-TO-CONSUMER GENETIC TESTS (2014).

181. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 179, at 2, 4.

182. *See* Andrew Pollack, *Walgreens Delays Selling Personal Genetic Test Kit*, N.Y. TIMES, May 12, 2010, at B5.

183. *See, e.g.*, FOOD & DRUG ADMIN., LETTER TO PATHWAY GENOMICS CORPORATION CONCERNING THE PATHWAY GENOMICS GENETIC HEALTH REPORT (May 10, 2010), http://www.fda.gov/MedicalDevices/ResourcesforYou/Industry/ucm211866.htm [http://perma.cc/UZV3-286W].

184. Mary Carmichael, *Why the FDA is Cracking Down on Do-It-Yourself Genetic Tests: An Exclusive Q&A*, NEWSWEEK (June 11, 2010, 10:00 AM), http://www.newsweek.com/why-fda-cracking-down-do-it-yourself-genetic-tests-exclusive-qa-222900 [http://perma.cc/2ZEY-UFQN].

185. Kayte Spector-Bagdady & Elizabeth Pike, *Consuming Genomics: Regulating Direct-to-Consumer Genomic Interpretation*, 92 NEB. L. REV. 677, 728 (2014). Pathway Genomics currently distributes its tests only to licensed physicians. *See How to Order a Pathway Genomics Test*, PATHWAY GENOMICS, https://www.pathway.com/ how-to-order-a-test/ [https://perma.cc/VF74-M9L6] (last visited Dec. 27, 2015).

186. Several companies offer ancestry-related genetic testing that clearly falls outside the scope of FDA regulation.

187. FOOD & DRUG ADMIN., DOC. NO. GEN1300666, FDA WARNING LETTER TO 23ANDME, INC. (2013), http://www.fda.gov/iceci/enforcementactions/warningletters/2013/ucm376296.htm [http://perma.cc/E7BP-5A22].

188. *Id.*

BRCA-related assessment of breast or ovarian cancer risk that could lead a patient to undergo prophylactic surgery.[189] Since such concerns are not limited to DTC testing (indeed, the same could be said about Myriad's BRCA test),[190] this action hinted at the agency's plan to move forward with regulation of all LDTs.

As the 23andMe saga unfolds, rapid advances in whole genome sequencing raise additional questions about FDA regulation of DTC genetic services. Gene By Gene Ltd. recently launched DNA DTC, which delivers complete genome sequences directly to consumers.[191] DNA DTC sells raw data only, perhaps to avoid attendant FDA scrutiny were it to provide interpretation and analysis.[192] To complement such "data-only" products, "interpretation-only" business models likely will someday enter the DTC commercial market.[193] It is unclear whether such purely interpretative services, separated from all laboratory work, would fall within the scope of the FDA's regulatory purview.[194] The agency's attempts to regulate interpretation services also would face First Amendment challenges.[195] If the FDA is barred from regulating pure interpretation, then companies seeking to offer comprehensive DTC services while skirting FDA review could employ a bifurcated model whereby consumers have their genomes sequenced by one entity and then submit raw sequence data to a different entity for health-related analysis.

---

189. *Id.*

190. Angelina Jolie's widely publicized decision to undergo prophylactic bilateral mastectomy after being tested by Myriad for BRCA-related cancer risk illustrates that such concerns are not limited to DTC services. *See* David Kroll, *How the Public and the Media Got Angelina Jolie's Breast Cancer Message Wrong*, FORBES (Dec. 24, 2013, 12:23 PM), http://www.forbes.com/sites/davidkroll/2013/12/24/whos-really-responsible-for-angelina-jolies-failure-as-a-breast-cancer-educator [http://perma.cc/8JEH-TG5K].

191. Dan Vorhaus, *DNA DTC: The Return of Direct to Consumer Whole Genome Sequencing*, GENOMICS L. REPORT (Nov. 29, 2012), http://www.genomicslawreport.com/index.php/2012/11/29/dna-dtc-the-return-of-direct-to-consumer-whole-genome-sequencing [http://perma.cc/NE7Q-F2R4].

192. *Id.* (speculating that DNA DTC might someday form a partnership with a future consumer-friendly "interpretation-only" genomics service to give consumers understandable genomic information).

193. Knome offers stand-alone interpretation for whole genome sequences provided by institutional clients. *See* KNOME, http://www.knome.com [http://perma.cc/RAV6-SL5C] (last visited Aug. 20, 2015) (including a disclaimer that the company's products and services are for research purposes only and Knome does not offer personal genomic analysis). A free stand-alone application called Promethease enables consumers to analyze their own genetic raw data, but its capabilities are rudimentary. *See Promethease*, SNPEDIA, http://www.snpedia.com/index.php/Promethease [http://perma.cc/2TW5-XQXK] (last visited Aug. 20, 2015). Another free service called openSNP enables people to upload their sequence data and "publish their test results, find others with similar genetic variations, learn more about their results, get the latest primary literature on their variations and help scientists find new associations." *See Welcome to openSNP*, OPENSNP, https://opensnp.org [https://perma.cc/Y8PF-KFZR] (last visited Aug. 20, 2015).

194. Historically, a key distinction has been drawn between medical products, which fall within the scope of the FDA's authority, and medical services, which fall outside its regulatory jurisdiction. *See, e.g.*, 37 Fed. Reg. 16,503, 16,504 (Aug. 15, 1972) (to be codified at 21 C.F.R. pt. 130) ("[I]t is clear that Congress did not intend the [FDA] to regulate or interfere with the practice of medicine . . . .").

195. *See* Spector-Bagdady & Pike, *supra* note 185, at 735–42.

B. Participatory Research and Patients' Rights To Information

The controversy over FDA regulation of genetic testing plays into a larger debate over the "struggle between medical (or government) paternalism and individuals' rights to information about ourselves."[196] Those who favor increased regulation argue that heightened FDA requirements would not deprive people of meaningful information and merely would require companies to prove that they can offer the services that they claim to provide.[197] Those who disfavor regulation stress that individuals should be permitted to decide for themselves whether they want to receive admittedly incomplete health information.[198] Therein lies a conundrum between restricting consumers' access to and improving the quality of genomic information. Currently most diagnostic genetic tests are relatively useless devices because they lack sufficient evidentiary support. Looser access restrictions will enhance data quality in the long term by increasing the number of participants willing and able to share DNA and information—but at the risk of misinforming and harming individuals in the meantime. Tensions between the desire to further the social goal of increasing collective scientific knowledge and the need to protect the interests of a diverse set of individual genetic sources—that is, patients and subjects—is another dimension to the commons problem in genomics research.[199]

The commercial genomics industry's long-term business strategy is not to sell tests, but to collect information from as many people as possible in order to create comprehensive, meaningful data sets for purchase and use by healthcare providers, pharmaceutical companies, and insurers. 23andMe is not only interested in consumers' DNA samples; it actively encourages them to opt in to research studies and volunteer to answer numerous questions about their personal and medical histories as well.[200] Its research arm, 23andWe, has secured federal grants

196. Annas & Elias, *supra* note 156, at 986.

197. *See, e.g.*, *id.* Supplementing federal regulation, several states either prohibit or limit DTC testing. *See* GENETICS & PUB. POL'Y CTR., SURVEY OF DIRECT-TO-CONSUMER TESTING STATUTES AND REGULATIONS (2007), http://www.dnapolicy.org/resources/DTCStateLawChart.pdf [https://web.archive.org/web/20130419160844/http://www.dnapolicy.org/resources/DTCStateLawChart.pdf].

198. *See, e.g.*, Robert C. Green & Nita A. Farahany, *Regulation: The FDA is Overcautious on Consumer Genomics*, 505 NATURE 286, 286 (2014), http://www.nature.com/news/regulation-the-fda-is-overcautious-on-consumer-genomics-1.14527 [http://perma.cc/XHF4-JN6Q] ("[A]s scholars who study how individuals respond to their own genetic information, we contend that the FDA's precautionary approach may pose a greater threat to consumer health than the harms that it seeks to prevent.").

199. Contreras, *supra* note 106, at 110 (noting "the recognition of human data subjects as important stakeholders in the genomic data equation").

200. *See Research*, 23ANDME, https://www.23andme.com/research [https://perma.cc/4XHQ-KYL6] (last visited Sept. 22, 2015) ("In order for scientists and researchers to accelerate healthcare, they need large sets of data. . .from all of us. Your research participation could contribute to findings in disease prevention, better drug therapies, disease treatments and ultimately, genetic paths to cures. Once you purchase your kit, you will have the choice to join this research revolution.").

and published in peer-reviewed journals.[201] Before the FDA discontinued 23andMe's PGS, the company ran a national advertising campaign touting that for ninety-nine dollars and submission of their DNA one could learn "hundreds of things about your health."[202] After it received the FDA's warning letter in 2013, the company was allowed only to give customers uninterpreted raw sequence data and ancestry-related information.[203] In February 2015, the FDA authorized 23andMe to market its Bloom syndrome carrier status genetic report.[204] But since such limited health service is much less attractive to consumers, FDA interference has severely hampered 23andMe's effort to develop a valuable information asset.

The advent of affordable genome sequencing coincides with the rise of a user-driven participatory health movement grounded in patient empowerment ideals. Participatory genomics taps into the ethos of citizen science exemplified by companies such as PatientsLikeMe, an online community whose members self-organize to conduct research and exchange medical information.[205] As with conventional collaborative research projects, participatory health initiatives manifest a diverse array of sharing arrangements. PatientsLikeMe recently signed a five-year agreement with biotechnology giant Genentech granting Genentech exclusive access to its proprietary database in exchange for an undisclosed fee.[206] Other participatory health projects emphasize altruism and communal scientific advancement. For example, Harvard Medical School's Personal Genome Project plans to sequence the genomes of 100,000 volunteers and contribute their genomic and medical record information to enable "public genomics."[207]

Participants enrich the genomic commons by supplying their biological material and personal information for research purposes. But as individual subjects play an increasingly active role in genomics research, they have asserted proprietary interests in the information that they help to generate. Individuals' growing desire to claim ownership of their health information is most clearly manifested by the "quantified self" community, whose members use a variety of

201. *See, e.g.*, Chuong B. Do et al., *Web-Based Genome-Wide Association Study Identifies Two Novel Loci and a Substantial Genetic Component for Parkinson's Disease*, 7 PLOS GENETICS e1002141 (2011).

202. *23andMe TV Commercial* (last aired Dec. 5, 2013), http://www.ispot.tv/ad/7qoF/23-and-me [http://perma.cc/TN9X-2G6P].

203. *Bring Your Ancestry to Life Through Your DNA*, 23ANDME, https://www.23andme.com/ancestry [https://perma.cc/2BUA-RDG8] (last visited Dec. 27, 2015) ("Get a personalized analysis of your DNA and discover your ancestral origins, trace your lineage and find new genetic relatives.").

204. *Our Service*, 23ANDME, https://www.23andme.com/service/ [https://perma.cc/HTR4-8RGE] (last visited Dec. 27, 2015) ("The first and only genetic service available directly to you that includes reports that meet FDA standards for being clinically and scientifically valid.").

205. *See Straight Talk with. . . Jamie Heywood*, 20 NATURE MED. 457, 457 (2014) ("What we get from the patients is essentially a clinical interview that asks about how the patient is doing, the symptomology of their disease, what drugs they're taking, what novel therapies they're trying, what supplements they're using and even lab values.").

206. *Id.*

207. John M. Conley, Adam K. Doerr & Daniel B. Vorhaus, *Enabling Responsible Public Genomics*, 20 HEALTH MATRIX 325, 330 (2010).

self-tracking applications and sensors to create and share personal data.[208] The emergence of this community reflects an evolving paradigm shift "from an era of intermittent, reactive health and medicine to one that is . . . . proactive and continuous while engaging and empowering the individual (whether a healthy consumer or a patient), clinician and healthcare system."[209]

Privacy is a major concern, and many worry that mechanisms to preserve data anonymity or confidentiality are inadequate.[210] Research participants also seek greater control over the data production process. Many desire affirmative rights to access and use information in addition to negative rights to prevent disclosure of personal data to third parties. People have expressed frustration that they cannot obtain user-generated data "that is siloed in proprietary platforms and interfaces."[211] The notion that patients and research subjects have property interests in the information that they help to create is reflected in the findings of a recent study, which reported that volunteers recruited to contribute to a genomic biobank repeatedly described their DNA in terms resembling the legal definition of a trade secret.[212] One scholar has advanced the argument that individuals have proprietary rights in their genetic and other bodily information to provocatively suggest that government-backed restrictions that block patient access to information violate a fundamental constitutional right under the due process clause.[213]

---

208. Sara M. Watson, *You Are Your Data*, SLATE (Nov. 12, 2013), http://www.slate.com/articles/technology/future_tense/2013/11/quantified_self_self_tracking_data_we_need_a_right_to_use_it.html [http://perma.cc/Q6VN-T9JW].

209. Daniel Kraft, *Our Health Is in Our Hands*, WIRED (May 16, 2014), http://www.wired.co.uk/magazine/archive/2014/05/features/our-health-in-our-hands [http://perma.cc/KR4E-JPV4] ("The benefits could range from low-cost genetic sequencing to the layering of distributed mobile devices and sensors, wearables and implantables."); *see also* Melanie Swan, *Health 2050: The Realization of Personalized Medicine Through Crowdsourcing, the Quantified Self, and the Participatory Biocitizen*, 2 J. PERS. MED. 93 (2012).

210. *See, e.g.*, Henry T. Greely, *The Uneasy Ethical and Legal Underpinnings of Large-Scale Genomic Banks*, 8 ANNUAL REV. HUM. GENETICS 343, 344 (2007) ("[P]atient identity is not, and cannot be, effectively protected in large-scale genomic biobanks."); K.B. Jacobs et al., *A New Statistic and Its Power to Infer Membership in a Genome-Wide Association Study Using Genotype Frequencies*, 41 NATURE GENETICS 1253 (2009); *see also* Julia Angwin & Steve Stecklow, *'Scrapers' Dig Deep for Data on Web*, WALL ST. J., Oct. 11, 2010, at A1 (reporting that PatientsLikeMe was subject to a "scraper" which connected health information to some site users' handles).

211. Watson, *supra* note 208.

212. John M. Conley, *A Trade Secret Model for Genomic Biobanking*, 40 J.L. MED. & ETHICS 612, 614 (2012).

213. Sapna Kumar, *Life, Liberty, and the Pursuit of Genetic Information*, 65 ALASKA L. REV. 625 (2014) (suggesting that diagnostic patents such as those at issue in *Myriad* are unconstitutional because they violate patients' fundamental rights under the due process clause to obtain information necessary to make informed medical decisions). One could extend this argument to assert that FDA regulation of genetic tests violates the Due Process Clause, although existing case law suggests that this would be a difficult argument to win. *See* Abigail Alliance for Better Access to Developmental Drugs v. von Eschenbach, 495 F.3d 695 (D.C. Cir. 2007) (en banc) (holding that terminally ill patients have no fundamental right under the due process clause to have access to experimental drugs not approved by the FDA).

Though some bioethicists have advocated restricting disclosure of information generated by genomics research,[214] participants often expect to receive results in exchange for their contributions to research studies.[215] Individuals' reasons for wanting genomic information vary: some value knowledge; some pursue a sense of identity or autonomy; some aim to advance a research goal; others seek recreational satisfaction.[216] The heterogeneous uses that patients and research subjects have for genomic information present additional challenges for policymakers to balance private and public interests in the genomic semicommons.

C. FDA as Genomic Information Intermediary

Though conventionally depicted as a drag on technological progress, FDA regulation actually may be a useful tool to ameliorate some of the innovation policy concerns left in *Myriad*'s wake. The FDA could address common-interest problems by leveraging its regulatory authority to coordinate the generation and use of genomic information.[217] A simple way for the agency to compel data sharing would be to assert its jurisdiction over all health-related genetic tests and mandate disclosure of all supporting data and interpretive methods as a condition of marketing approval. But such heavy-handed disclosure rules likely would run afoul of federal laws that prevent agencies from revealing regulated entities' trade secrets.[218] They also might violate the takings clause of the U.S. Constitution.[219] Moreover, comprehensive disclosure rules would dampen incentives to produce clinically useful information where developers cannot rely on patent protection to recoup their R&D investments.[220] Innovation policy goals would be better served

214. *See, e.g.*, Annelien L. Bredenoord & Johannes J.M. van Delden, *Research Ethics in Genomics Research: Feedback of Individual Genetic Data to Research Participants*, *in* HUMAN MEDICAL RESEARCH 127, 128–29 (J. Schildmann et al. eds., 2012).

215. Juli Murphy Bollinger et al., *Public Preferences Regarding the Return of Individual Genetic Research Results: Findings from a Qualitative Focus Group Study*, 14 GENETICS MED. 451, 451 (2012).

216. *See*, *e.g.*, Brendan Maher, *Poll Results: Nature Readers Flirt with Personal Genomics*, 478 NATURE 1, 4 (2011).

217. *See* Fennell, *supra* note 136, at 985 (noting that a centralized figure can ameliorate strategic problems by coordinating a response).

218. Under the Federal Trade Secrets Act, a federal employee is prohibited from disclosing "any information" that relates to "trade secrets, processes, operations, style of work, or apparatus" if the information was obtained in the course of his employment. 18 U.S.C. § 1905 (2012); *see, e.g.*, Tri-Bio Labs., Inc. v. United States, 836 F.2d 135, 141 n.7 (3d Cir. 1987) (stating that the Federal Trade Secrets Act prohibits FDA disclosure of "application data").

219. The Fifth Amendment of the U.S. Constitution states: "[N]or shall private property be taken for public use, without just compensation." U.S. CONST. amend V; *see* Richard A. Epstein, *The Constitutional Protection of Trade Secrets Under the Takings Clause*, 71 U. CHI. L. REV. 57, 58 (2004) (discussing application of the takings clause to trade secrets).

220. Mandatory disclosure of proprietary information could be coupled with FDA-administered data and market exclusivities like those that are available for innovative drugs. *See* Eisenberg, *supra* note 159, at 359–61 (discussing FDA-administered "pseudo-patents"). This would require new legislation, since currently there are no FDA-administered exclusivities for devices. Also,

by more tailored exercises of the FDA's market gatekeeping power. A less coercive scheme could facilitate data sharing by managing information flows across open and proprietary spaces.[221]

Existing regulations governing medical product information provide a template for the FDA to coordinate the generation and use of genomic data. Although genetic tests are devices, not drugs, the manner in which the FDA mediates between brand and generic pharmaceutical manufacturers illustrates how the agency acts as an information intermediary in carrying out its regulatory functions. Prior to the passage of the Drug Price Competition and Patent Term Restoration Act of 1984 (generally known as the Hatch-Waxman Act, or "Hatch-Waxman"), regulatory barriers created by FDA approval requirements were high enough to keep generic equivalents of most drugs off the market long after patent expiration.[222] This was because the FDA treats as confidential the costly safety and efficacy data pioneers generate to obtain product licenses, and generic manufacturers lack incentives to incur the costs of performing their own clinical trials.[223] In protecting pioneers' clinical trials data as trade secrets, the agency enforces proprietary rights in information that, prior to Hatch-Waxman, effectively deterred generic competition even after the elimination of patent obstacles.

Hatch-Waxman directed the FDA to essentially mediate information exchange between competing drug manufacturers by preserving pioneer firms' trade secrets while simultaneously facilitating structured free riding. The Act allows an Abbreviated New Drug Application (ANDA) to be approved upon a showing of bioequivalence to a previously approved product, without repeating clinical trials to prove safety and effectiveness.[224] But it does not allow generic companies to access pioneer firms' raw data. Rather, through the ANDA pathway, generic firms indirectly rely on brand manufacturers' confidential information upon expiration or invalidation of brand manufacturers' patents.[225] Hatch-

---

such exclusivities would result in supracompetitive prices and thus would, like patents, reduce consumer surplus during exclusivity periods.

221. *See* Robert B. Ahdieh, *Law's Signal: A Cueing Theory of Law in Market Transition*, 77 S. CAL. L. REV. 215, 229–32 (2004) (describing a noncoercive role for regulation in facilitating coordination); Ahdieh, *supra* note 158, at 623 ("An important function for regulatory authorities in coordination settings . . . lies in soliciting, generating, compiling, and distributing technical and market information.").

222. Pub. L. No. 98-417, § 101, 98 Stat. 1538, 1585 (1984) (codified as amended at 35 U.S.C. § 156 (2012)).

223. *See* Rebecca S. Eisenberg, *Data Secrecy in the Age of Regulatory Exclusivity*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF CONTEMPORARY RESEARCH, *supra* note 114, at 467 (noting that the FDA withholds public disclosure of clinical trials data pursuant to Exemption 4 of the Freedom of Information Act, 5 U.S.C. § 552(b)(4), which exempts "matters that are . . . trade secrets and commercial or financial information obtained from a person and privileged or confidential"); Gerald J. Mossinghoff, *Overview of the Hatch-Waxman Act and its Impact on the Drug Development Process*, 54 FOOD & DRUG L.J. 187 (1999).

224. 21 U.S.C. § 355(j) (2012).

225. *See* Anna B. Laakmann, *The Hatch-Waxman Act's Side Effects: Precautions for Biosimilars*, 47

Waxman also preserves pioneers' incentives to produce safety and efficacy data by, *inter alia*, granting five years of FDA-administered data exclusivity to the sponsors of innovative drugs.[226] The Hatch-Waxman scheme thereby uses FDA licensing requirements to encourage continued generation of clinically useful information and to facilitate staged, agency-mediated use of that information. Importantly, this system operates in tandem with the patent system and manages the allocation of proprietary rights under conditions in which relevant patents can no longer be enforced.

A similar, more ad hoc series of compromises between innovators and copiers is woven into the regulation of medical devices. Under the 1976 Medical Device Amendments to the FFDCA, the FDA sets evidentiary requirements for manufacturers by placing devices into one of three categories based on health risks associated with their use. Manufacturers of Class III devices that either "present a potential unreasonable risk of illness or injury," or which are "purported or represented to be for a use in supporting or sustaining human life or for a use which is of substantial importance in preventing impairment of human health" must provide the FDA with "reasonable assurance" that their devices are safe and effective before they can be introduced to the market.[227] The Act includes a grandfathering provision that allows devices that were sold before the enactment of the Amendments to remain on the market.[228] To encourage competitors to develop improved versions of grandfathered pre-1976 products, the Act also permits devices that are "substantially equivalent" to preexisting devices to enter the market via a streamlined notification process referred to as a "§ 510(k)."[229]

The 510(k) process for medical devices loosely resembles the ANDA pathway for generic drugs.[230] Eligible devices can be marketed without substantial regulatory review, at least until the FDA sets evidentiary requirements for approval of the predicate pre-1976 device.[231] This puts manufacturers of similar

---

LOY. L.A. L. REV. 917, 920 (2014) (emphasizing the significance of Hatch-Waxman's effects on the drug industry by noting that generics accounted for eighty-four percent of all U.S. prescriptions in 2012, compared to only nineteen percent in 1984).

226. Eisenberg, *supra* note 159, at 359–60 ("[T]hese provisions amount to FDA-administered proprietary rights in regulatory data . . . . The practical effect is to defer generic competition, even without patent protection.").

227. 21 U.S.C. §§ 360c(1)(C), 360e(d)(2).

228. § 360e(b)(1)(A).

229. § 360e(b)(1)(B). This process is referred to as a section 510(k) after the number of the section in the original statute.

230. In 2011, the FDA released guidance to establish a *de novo* program designed to allow low- to moderate-risk devices on the market even without substantially equivalent predicates, which is the process that it has used to consider genetic tests. Some sections of the guidance may no longer be current as a result of the Food and Drug Administration Safety and Innovation Act (FDASIA) signed into law on July 9, 2012. *See* Food & Drug Admin., De Novo Classification Process (Evaluation of Automatic Class III Designation): Draft Guidance for Industry and Food and Drug Administration Staff (Aug. 14, 2014) (unpublished guidance document), http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM273903.pdf [https://perma.cc/L92E-RVFZ].

231. Medtronic, Inc. v. Lohr, 518 U.S. 470, 478 (1996).

devices on equal footing with respect to information production burdens. Breakthrough medical-device manufacturers face much higher regulatory hurdles under this scheme, since Class III devices that do not sufficiently resemble products that were on the market before 1976 must undergo comprehensive premarket review and cannot use the § 510(k) notification process. To counteract perverse incentives created by this disparity, the FDA has launched "Innovation Pathway 2.0," a series of initiatives designed to promote development of breakthrough devices by reducing the timeline and cost of generating safety and efficacy data.[232]

The FDA further acts as an information intermediary by using its labeling authority to certify the credibility of drug and device manufacturers' marketing claims. In addition to specifying the type and amount of data that manufacturers must generate before they can communicate with patients and physicians about intended uses of their products, the FDA filters how interpretations of that data are conveyed in product labels.[233] Without revealing manufacturers' trade secrets and confidential information, the agency also publicly discloses analyses of underlying data used to support marketing claims.[234] The FDA could build upon this model to mediate the exchange of genomic information among clinical diagnostics developers, physicians, and patients. Licensing requirements for diagnostic tests could be set to drive information production, and the agency could coordinate a sharing regime through structured, staged disclosure of proprietary genomic data. For instance, approval of diagnostic genetic tests might be conditioned on deposit of newly discovered variants into a centralized public database, with manufacturers permitted to keep undisclosed proprietary algorithms and aggregate data sets.

Existing regulations governing the marketing and labeling of medical devices could be adapted to address the unique issues raised by complex genetic tests. In particular, the agency could exercise its licensing authority to address difficult questions about when end users should be able to gain access to ambiguous information. Should test manufacturers be required to meet strict clinical validity benchmarks before informing patients and physicians of correlations between genetic data and disease risk? Or should instead the FDA merely require disclosure of interpretive uncertainties and allow the market to determine the value of more definitive analyses? In answering these questions, the agency would need to decide whether to offer consumers a choice between more costly, information-rich and less expensive, information-poor diagnostic products. The FDA could elect to set different data production requirements for genetic test providers that deliver information for purposes of diagnosis and treatment, and

232. *See Innovation Pathway*, FDA, http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/CDRH/CDRHInnovation/InnovationPathway/default.htm [http://perma.cc/J44G-NU74] (last visited Aug. 20, 2015).

233. Eisenberg, *supra* note 159, at 370–72.

234. *Id.* at 382.

those that do so for educational purposes, analogous to the two-tiered regulatory scheme for drugs and dietary supplements.[235]

As explained in Section III.A, interpretation only" genetic tests may fall outside the FDA's regulatory purview. However, purely interpretive clinical genomics companies might nonetheless voluntarily seek regulatory approval in order to signal the credibility of their results to patients and physicians and to qualify for insurance reimbursement. Alternatively, third-party certification bodies could be created to assess the quality of genomic services that the FDA lacks the authority to regulate.[236]

A comprehensive analysis of the ways in which the regulatory system could be employed to resolve common-interest problems in biomedical research is beyond the scope of this Article. The more modest goal here is to highlight the interplay between intellectual property and regulatory regimes and to advocate more holistic treatment of the ways in which they encourage (or discourage) the generation and exchange of information. I leave for separate work further exploration of the overlapping, complementary roles that these systems play in governing knowledge production.[237]

CONCLUSION

Gene patents have raised controversy since the early days of biotechnology. Many observers hoped that the Supreme Court in *Myriad* would settle the debate and clarify the patent eligibility of genomic discoveries. Regrettably, while the Court did set new limitations on patenting DNA sequences, it simultaneously perpetuated legal uncertainty that threatens to stall the advance of personalized medicine. Heightened patent-eligibility requirements designed to avert an anticommons tragedy in genomics research risk creating a commons tragedy by destabilizing sharing regimes. Collective action problems that have been exacerbated by this decision should be addressed with organized efforts to manage interdependent public and private interests in the genomic semicommons. FDA regulation could play a helpful role in creating incentives to generate and share patent-ineligible discoveries and should be crafted to evolve synergistically with the intellectual property system to facilitate cooperative innovation.

---

235. *See* Eisenberg, *supra* note 159, at 379–80 (noting the uneven regulatory regime applied to drugs and dietary supplements). Some commentators have argued that there is a distinction under the FFDCA between products for diagnosis of disease and products for general "wellness." *See* MHEALTH REGULATORY COALITION, A CALL FOR CLARITY: OPEN QUESTIONS ON THE SCOPE OF FDA REGULATION OF MHEALTH 9 (2010).

236. Congress has authorized a limited system of third-party reviews for certain FDA-regulated devices. *See* 21 U.S.C. § 360m (2012).

237. *See* Anna B. Laakmann, *A Property Theory of Medical Innovation* (unpublished) (on file with author).